TRANSACTIONS

OF

THE INSTITUTION

OF

MINING ENGINEERS.

VOL. XVI.—1898-99.

EDITED BY M. WALTON BROWN, SECRETARY.

NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTION.

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1899.

ADVERTIZEMENT.

The Institution, as a body, is not responsible for the statements, facts and opinions advanced in any of its publications.

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THE MINING INSTITUTE OF SCOTLAND.

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LIST OF PLATES:—

THE INSTITUTION OF MINING ENGINEERS.

OFFICERS, 1898-99.

President.

Mr. J. A. LONGDEN, Stanton-by-Dale, near Nottingham

Vice-Presidents.

Mr. W. N. ATKINSON, Barlaston, Stoke-upon-Trent (Past-President).
Mr. WILLIAM ARMSTRONG, Wingate, Co. Durham.
Mr. WILLIAM HENRY CHAMBERS, Conisborough, Rotherham.
Mr. W. COCHRANE, St. John's Chambers, Grainger Street West, Newcastle-upon-Tyne.
Mr. J. T. FORGIE, Bothwell Collieries, Bothwell, Glasgow.
Mr. G. B. FORSTER, 3, Eldon Square, Newcastle-upon-Tyne; and Farnley Hill, Corbridge-upon-Tyne.
Mr. JAMES HAMILTON, 208, St. Vincent Street, Glasgow.
Mr. W. D. HOLFORD, Hill House, Old Whittington, Chesterfield.
Mr. GEORGE LEWIS, Albert Street, Derby (Past-President).
Sir WILLIAM THOMAS LEWIS, Bart., Mardy, Aberdare.
Mr. GEORGE MAY, The Harton Collieries, South Shields.
Mr. M. H. MILLS, Sherwood Hall, Mansfield.
Mr. GEORGE A. MITCHELL, 5, West Regent Street, Glasgow (Past-President).
Mr. JOEL SETTLE, The Hill, Alsager, Stoke-upon-Trent.
Mr. J. B. SIMPSON, Bradley Hall, Wylam-upon-Tyne. *
Mr. A. SOPWITH, Cannock Chase Collieries, near Walsall (Past-President).
Mr. G. BLAKE WALKER, Wharncliffe Silkstone Colliery, Barnsley.
Mr. JAMES WALLACE, Wester Gartshore Colliery, Kirkintilloch, Glasgow.
Mr. R. S. WILLIAMSON, Cannock Wood House, Hednesford, Staffordshire.
Sir LINDSAY WOOD, Bart., The Hermitage, Chester-le-Street (Past-President).

Council.

* Deceased.

Mr. HENRY ARMSTRONG, Chester-le-Street.
Mr. J. B. ATKINSON, 10, Foremount Terrace, Glasgow.
Mr. HENRY AYTON, 122, Rye Hill, Newcastle-upon-Tyne.
Mr. R. DONALD BAIN, Springwell Hall, Durham.
Mr. JAMES BARROWMAN, Staneacre, Hamilton, N.B.
Mr. T. W. BENSON, 24, Grey Street, Newcastle-upon-Tyne.
Mr. G. J. BINNS, Duffield House, Duffield, near Derby.
Mr. BENNETT H. BROUGH, Cranleigh House, Woodham, near Addlestone, Surrey.
Mr. M. WALTON BROWN, 10, Lambton Road, Newcastle-upon-Tyne.
Mr. H. M. CADELL, Grange, Bo'ness, R.S.O., Linlithgowshire.
Mr. G. E. COKE, 65, Station Street, Nottingham.
Mr. M. DEACON, Whittington House, near Chesterfield.
Mr. JAMES S. DIXON, Fairleigh, Bothwell, N.B.

Mr. H. St. John Durnford, Ackton Hall Colliery, Featherstone, near Pontefract.
Mr. T. E. Forster, 3, Eldon Square, Newcastle-upon-Tyne.
Mr. W. E. Garforth, West Riding Colliery, Normanton.
Mr. John Gerrard, Worsley, Manchester.
Mr. Nath. R. Griffith, Plasnewydd, Ruabon, North Wales.
Mr. J. R. Haines, Adderley Green Collieries, Stoke-upon-Trent.
Mr. W. F. Hall, Haswell Colliery, Haswell, *via* Sunderland.
Mr. James Hastie, Greenfield Colliery, Hamilton, N.B.
Mr. W. J. Hayward, West Bromwich.
*Mr. J. Head, 47, Victoria Street, Westminster, London, S.W.
Mr. Archibald Hood, 6, Bute Crescent, Cardiff.
Mr. James A. Hood, Rosewell, Midlothian.
*Mr. W. F. Howard, Ivy Grove, Clarence Road, Chesterfield.
*Mr. J. Jackson, Stubben Edge, Chesterfield.
Mr. A. C. Kayll, Gosforth, Newcastle-upon-Tyne.
Mr. Henry Lawrence, 24, Grainger Street West, Newcastle-upon-Tyne.
Mr. G. A. Lewis, Penshurst, Charnwood Street, Derby.
Mr. H. Lewis, Annesley Colliery, Nottingham.
Mr. J. Longbotham, Sharrow House, Sheffield.
Mr. Henry Louis, 9, Summerhill Terrace, Newcastle-upon-Tyne.
Mr. Hugh R. Makepeace, Newcastle, Staffordshire.
Mr. Henry W. Martin, Trewern, Dowlais, Glamorganshire.
Mr. T. W. H. Mitchell, Mining Offices, Barnsley.
Mr. C. A. Moreing, Broad Street House, Old Broad Street, London, E.C.
Mr. J. Morison, Cramlington House, Northumberland.
Mr. H. B. Nash, Clarke's Old Silkstone Colliery, Barnsley.
Mr. J. Nevin, Littlemoor House, Mirfield.
Mr. H. Palmer, Medomsley, R.S.O., Co. Durham.
Mr. H. C. Peake, Walsall Wood Colliery, Walsall.
Mr. John Ridyard, Hilton Bank, Little Hulton, Bolton-le-Moors, Lancashire.
Mr. J. M. Ronaldson, 44, Athole Gardens, Glasgow.
Mr. Fred. J. Rowan, 121, West Regent Street, Glasgow.
Mr. A. R. Sawyer, P.O. Box 2233, Johannesburg, Transvaal; and Hilhouse, Woking, Surrey.
Mr. F. R. Simpson, Hedgefield House, Blaydon-upon-Tyne.
Mr. Alex. Smith, 3, Newhall Street, Birmingham.
Mr. A. L. Steavenson, Durham.
Mr. J. Strick, Bar Hill, Madeley, Staffordshire.
Mr. E. W. Thirkell, Oaks Colliery, Barnsley.
Mr. Wallace Thorneycroft, 25, Snowdon Place, Stirling, N.B.
Mr. E. B. Wain, Whitfield Collieries, Norton-in-the-Moors, Stoke-upon-Trent.
Mr. F. N. Wardell, Wath-upon-Dearne, near Rotherham.

Auditors.

Messrs. John G. Benson & Son, Newcastle-upon-Tyne.

Treasurers.

Messrs. Lambton and Company, Bankers, Newcastle-upon-Tyne.

Secretary.

Mr. M. Walton Brown, Neville Hall, Newcastle-upon-Tyne.

THE INSTITUTION OF MINING ENGINEERS.

SUBJECTS FOR PAPERS.

The Council of The Institution of Mining Engineers invite original communications on the subjects in the following list, together with other questions of interest to mining and metallurgical engineers.

For selected papers, the Council may award prizes. In making awards, no distinction is made between communications received from members of the Institution or others.

Assaying.
Blowing out of coal and minerals *in situ*.
Boiler explosions.
Bore-holes and prospecting.
Boring against water and gases.
Brickmaking by machinery.
Brine-pumping.
Canals, inland navigation, and the canalization of rivers.
Coal-getting by machinery.
Coke manufacture.
Colliery explosions.
Colliery leases, and limited liability companies.
Compressed air as a motive-power.
Consumption of steam and water in engines.
Descriptions of coal-fields.
Diamond-mining.
Distillation of oil-shales.
Drift and placer-mining.
Duration of coal-fields of the world.
Electric mining lamps.
Electricity and its applications in mines.
Electro-metallurgy of copper.
Engine-counters and speed-recorders.
Explosions in mines.
Explosives used in mines.
Faults and veins.
Fuels and fluxes.
Gas producers, and gaseous fuel and illuminants.
Gas, oil and petroleum engines.
Geology and mineralogy.
Haulage in mines.
Industrial assurance.
Inspection of mines.
Laws of mining and other concessions.
Lead-smelting.
Lubrication of trams and tubs.
Maintenance of canals in mining districts.
Manufacture of fuel-briquettes.
Mechanical preparation of ores and minerals.
Mechanical ventilation of mines, and efficiency of the various classes of ventilators.
Metallurgy of gold, silver, iron, copper, lead, etc.
Mineral resources of colonies.
Mining and uses of asbestos, bauxite, etc.
Occurrence of mineral ores, etc.
Ore-sampling machines.
Petroleum-deposits.
Prevention of over-winding.
Pumping machinery.
Pyrometers and their application.
Quarries and methods of quarrying.
Rectification of mineral oils.
Safety-lamps.
Salt-mining, etc.
Screening, sorting and cleaning of coal.
Shipping and discharge of coal-cargoes.
Sinking, coffering and tubbing of shafts.
Smelting.
Spontaneous ignition of coal and coal-seams.
Submarine coal-mining.
Sulphur-mining.
Surface-arrangements of mines.
Surveying.
Tin-mining.
Tunnelling, methods and appliances.
Utilization of dust and refuse coal.
Utilization of sulphureous gases resulting from metallurgical processes.
Ventilation of coal-cargoes.
Ventilation of mines.
Water as a motive-power in mines.
Watering coal-dust.
Water-incrustations in boilers, pumps, etc.
Winding arrangements at mines.
Winning and working of mines at great depths.

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TRANSACTIONS

OF

THE INSTITUTION

OF

MINING ENGINEERS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, AUGUST 6TH, 1898.

MR. GEO. MAY, RETIRING PRESIDENT, IN THE CHAIR

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on July 23rd and that day.

The SECRETARY also reported the proceeding of the Council of The Institution of Mining Engineers.

ELECTION OF OFFICERS, 1898-99.

The CHAIRMAN (Mr. G. May) appointed Messrs. J. W. Fryar, C. H. Steavenson, W. Ridley, and W. R. Bell as scrutineers of the balloting-papers for the election of officers for the year 1898-99. The scrutineers afterwards reported the result of the ballot as follows:—

PRESIDENT.

Mr. WILLIAM ARMSTRONG.

VICE-PRESIDENTS.

Mr. T. W. BENSON.
Mr. T. FORSTER BROWN.
Mr. J. L. HEDLEY.
Sir WILLIAM THOMAS LEWIS.
Mr. R. ROBINSON.
Mr. J. G. WEEKS.

COUNCIL.

Mr. HENRY AYTON.	Prof. H. LOUIS.
Mr. W. C. BLACKETT.	Mr. C. W. MARTIN.
Mr. BENJAMIN DODD.	Mr. J. H. MERIVALE.
Mr. T. E. FORSTER.	Mr. H. PALMER.
Mr. W. F. HALL.	Mr. A. M. POTTER.
Mr. T. E. JOBLING.	Mr. J. A. RAMSAY.
Mr. A. C. KAYLL.	Mr. T. O. ROBSON.
Mr. H. LAWRENCE.	Mr. F. R. SIMPSON.
Mr. W. LOGAN.	Mr. J. SIMPSON.

Mr. G. B. FORSTER proposed a vote of thanks to the retiring President (Mr. G. May), Vice-Presidents and Councillors for their services during the past year.

Mr. W. C. BLACKETT seconded the resolution, which was cordially adopted.

Mr. P. KIRKUP moved, and Mr. M. WALTON BROWN seconded, that a vote of thanks be accorded to the scrutineers for their services, which was unanimously adopted.

The Annual Report of the Council was read as follows :—

ANNUAL REPORT OF THE COUNCIL, 1897-98.

The following table shows the number of members of the various classes during a few recent years:—

	August 1st. 1896.	1897.	1898.
Honorary Members...	23	29	30
Members	767	829	859
Associate Members...	78	98	115
Associates	83	91	103
Students	46	45	51
Subscribers	23	23	22
Totals	1,020	1,115	1,180

The Council are pleased to report a continued expansion of the membership as recorded in the preceding table, and urge the members to endeavour, at all times, to extend it. The class of Associates, comprizing persons employed in subordinate positions in mines, has proved successful, and has materially assisted in increasing the roll of members.

The members have to regret the deaths of Mr. Thomas John Bewick, Mr. Stephen Campbell Crone, and Mr. William Lishman (Sunderland), who had for many years been actively connected with the Institute, and had served on the Council.

With the view of rendering the Wood Memorial Hall more useful to the members, the Council have had plans prepared for lighting from the roof, extension of the book-shelving, erection of entrance-porch, furnishing, warming, decoration, etc., at an estimated cost of about £2,000. The work is now in progress, and it is hoped that the alterations will be completed on September 1st next ensuing.

With the view of reducing the expenses of the Institute, the Council have agreed to let Room No. 4, now held under lease, to the Coal Trade Associations, at a rental of £75 per annum, for a term of 7 years, from November 11th, 1897.

A portrait of the late Sir George Elliot has been presented by his grandson, Sir George Elliot. The Council trust that the series of portraits of Past-Presidents may be completed by gift or bequest, and that succeeding Presidents will each in rotation assist in maintaining the completion of this collection.

The meetings of Students and Associates have been continued, and one paper has been printed in the *Transactions*.

The revision of the composition, payable in lieu of the annual subscription, has been approved, as shown by the number of members who have so compounded. The Council will invest the amounts so received, as suitable investments are suggested to them.

The additions to the Library by donation, exchange, and purchase have been :—

Bound volumes	286	
Pamphlets, reports, etc.	246	
A total of	532	titles.

and the Library now contains about 7,739 volumes and 1,750 unbound pamphlets. The Card Catalogue renders the books readily available for reference. The Library (including the books and weekly engineering papers) is available to members residing in the vicinity, from 10 a.m. to 5 p.m. daily, and those residing at a distance may make use of the books by communication with the Secretary. Some of the files of publications have been rendered incomplete by the neglect of members to return borrowed books, and it is earnestly requested that members will return the missing volumes.

The Library would be rendered more valuable if members would present volumes, etc., which they can spare from their own libraries. Members would also render valuable service to the profession by bequeathing books, reports, plans, etc., to the Library, where they would be available for reference, and maintain the memory of the donor.

By arrangement with the Literary and Philosophical Society of Newcastle-upon-Tyne, whose premises are connected with the Library of the Institute, members of either institution are permitted (on producing a member's pass) to refer to the books in the Library of either institution.

The publication of the *Sinkings and Borings* has been completed, and the series of six volumes may be purchased from the Secretary. Members are desired to send copies of any unpublished sections of strata in Durham or Northumberland, or their section-books on loan, to the Secretary, with the view of their being published in a supplementary volume.

The prices of the *Transactions* and other publications of the Institute have been reduced, and members are recommended to complete their sets before the stock is exhausted (volumes iii. to vi. are now out of print).

A General Index to volumes i. to xxxviii. of the *Transactions* of the Institute is in preparation, and the Council trust that it will be received with approval by the members.

The Council suggest that Indian and Colonial members should arrange local meetings for the reading and discussion of papers, and trust that success will attend such efforts.

The report of the Committee on Mechanical Ventilators is approaching completion, and will be issued during the current year to the members.

Mr. John Herman Merivale has been appointed to represent the Institute at the Conference of Corresponding Societies of the British Association for the Advancement of Science at Bristol in September next. Messrs. James McMurtrie and W. B. Harrison will represent the Institute at the meeting of the Sanitary Institute to be held in Birmingham in September next. Mr. John Daglish acts on behalf of the Institute as a governor of the Durham College of Science, Newcastle-upon-Tyne. Mr. W. Cochrane is the Institute representative on the Science and Art Committee; and Mr. Henry Ayton, on the Scholarships Committee of the Northumberland County Council.

The Federated Institution of Mining Engineers has now become The Institution of Mining Engineers, and the Council urge the members, who may be interested in other societies, to use their influence in favour of federation, by which the success of the Institution will be completely assured.

The Institution of Mining Engineers has now completed its ninth year, during which General Meetings have been held in Edinburgh, on September 14th, 15th and 16th, 1897; in Newcastle-upon-Tyne, on

February 22nd, 23rd and 24th, 1898; and in London, on May 19th, 20th and 21st, 1898. A meeting of students, associates, and junior members was held in Newcastle-upon-Tyne, on August 18th, 19th and 20th, 1897. The meetings held in this district were well attended, and the thanks of the Institute are due to the Committees who made the arrangements, and to all of those who, by their services, contributed to the holding of these successful meetings.

The President's (Mr. George May) students' prize was awarded to Mr. G. P. Chaplin, for his paper on "Cornish Methods of Mine-timbering."

Prizes of books have been awarded the writers of the following papers, communicated to the members during the year 1896-7:—

"The Gold-fields of the Hauraki Peninsula, New Zealand." By the Rev. Joseph Campbell.

"Cornish Methods of Mine-timbering." By Mr. G. P. Chaplin.

"The Mineral Resources of the Colony of Queensland." By Mr. William Fryar.

"Notes on the Coal-seams of the Transvaal, and Description of a Modern Pit-head Plant." By Mr. W. T. Hallimond.

"Notes upon Foreign Mining Laws and Adequate Areas for Mining Concessions." By Mr. H. D. Hoskold.

"The Education of Metallurgists." By Mr. Saville Shaw.

"Notes on the Sinking of Two Shafts at Claravale Colliery." By Mr. F. R. Simpson.

The papers communicated during the year comprize:—

"Pyritic Smelting." By Mr. Wm. Lawrence Austin.

"Experiments with the Shaw Gas-tester." By Dr. P. P. Bedson and Mr. J. Cooper, B.Sc.

"Memoir of the late Mr. Thomas John Bewick, M. Inst. C E., F.G.S." By Mr. T. B. Bewick.

"Notes on Rearer Workings." By Mr. John Cadman.

"Secondary Haulage: Cost of Putting and Driving." By Messrs. T. E. Forster and F. R. Simpson.

"Notes on the Geology of Finland." By Principal H. Palin Gurney.

"Notes on the Iron Industry in the Urals." By Prof. H. Louis.

"Presidential Address." By Mr. George May.

"Occurrences and Mining of Manjak in Barbados, West Indies." By Mr. Walter Merivale.

"The Siliceous Iron-ores of Northern Norway." By Mr. H. T. Newbigin.

"The Gold-regions of Alabama, U.S.A." By Mr. Wm. B. Phillips.

"Hydrothermal Gold-deposits at Peak Hill, Western Australia." By Mr. Frank Reed, Inspector of Mines.

"A Method of dealing with Running-sand when met with in Borings." By Mr. Geo. B. Reynolds.

The members may be congratulated upon the number and varied nature of the papers printed in the *Transactions*, and the Council trust that similar contributions will be forwarded as liberally as heretofore.

In conclusion, the Council desire to impress upon the members that the success of the Institute in the future is dependent upon an increase in the membership, so as to meet the increased expences incurred by its connexion with The Institution of Mining Engineers.

The CHAIRMAN moved the adoption of the report.

Mr. THOMAS DOUGLAS, in seconding the resolution, regretted the death of three gentlemen with whom he had been personally connected in former years, and whose demise it had been necessary to place on record.

The report was unanimously adopted.

The TREASURER read the Report of the Finance Committee as follows :—

REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts from August 1st, 1897, to June 30th, 1898, covering a period of only eleven months. This is in consequence of the Council having decided that the books shall in future be closed on June 30th in each year, in order to allow greater time for the preparation and audit of the accounts than was possible when they were closed on July 31st and submitted to the annual meeting at the beginning of August. Owing to this change, a proper comparison with the accounts of the previous year cannot be instituted.

The total income during the period named was £2,749 9s. 6d. Of this amount, £113 was paid as life-compositions in lieu of annual subscriptions, and £89 11s. 10d. was received from the South Wales Institute of Engineers and The Institution of Mining Engineers, in repayment of moneys previously expended by this Institute in connexion with the Fan Committee's Report, leaving £2,546 17s. 8d. as the ordinary income.

The names of several members whose subscriptions were in arrear have been struck off the list of members, and the amounts written off in consequence are for the current year £48 6s. 0d., and arrears £67 4s. 0d.

The total expenditure amounted to £1,883 16s. 0d., and the sum of £950 has been placed on deposit with the bankers.

During the month of July, additional subscriptions have been received amounting to £114 9s. 0d., and payments have been made of £284 11s. 6d., including £200 on account of the alterations to the Wood Memorial Hall, so that the balance of capital at July 31st was £9,278 12s. 11d., as compared with £8,769 13s. 1d. at July 31st, 1897.

The CHAIRMAN (Mr. G. MAY), in proposing the adoption of the Report of the Finance Committee, said that the members could congratulate themselves upon the continued success of the Institute.

Mr. G. B. FORSTER seconded the motion, which was unanimously adopted.

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND
FOR THE YEAR ENDING

		£ s. d.	£ s. d.
July 31st, 1897.			
To Balance at Bankers		725 10 6	
„ „ in Treasurer's hands		100 0 0	
„ Outstanding Amounts due for Authors' Excerpts	£5 7 5		
Less—Written off	3 6 9		
		2 0 8	
July 31st, 1898.			827 11 2
To Dividend of 7½ per cent. on 146 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd., for year ending June, 1898		219 0 0	
„ Interest on Mortgage of £1,400 with Institute and Coal Trade Chambers Company, Ltd.		24 10 0	
			243 10 0
„ South Wales Institute of Engineers, proportion of Fan Committee Expenses		34 6 8	
„ The Institution of Mining Engineers, repayment of do.		55 5 2	
			89 11 10
„ Sales of Transactions			52 3 8
To SUBSCRIPTIONS FOR 1897-98 AS FOLLOWS:—			
690 Members	@ £2 2s.	1,449 0 0	
69 Associate Members	@ £2 2s.	144 18 0	
79 Associates	@ £1 1s.	82 19 0	
35 Students	@ £1 1s.	36 15 0	
75 New Members	@ £2 2s.	157 10 0	
30 New Associate Members	@ £2 2s.	63 0 0	
15 New Associates	@ £1 1s.	15 15 0	
11 New Students	@ £1 1s.	11 11 0	
		1,961 8 0	
To SUBSCRIBING FIRMS, VIZ.:—	£ s. d.		
1 @ £4 4s.	4 4 0		
1 @ £2 2s.	2 2 0		
		6 6 0	
To NEW SUBSCRIBING FIRMS, VIZ.:—			
2 @ £4 4s.		8 8 0	
		1,976 2 0	
To LIFE COMPOSITIONS:—			
2 Members	£41 0 0		
1 New Member...	24 0 0		
2 New Associate Members	48 0 0		
		113 0 0	
		2,089 2 0	
Less—Subscriptions for current year paid in advance at the end of last year...		49 7 0	
		2,039 15 0	
Add—Arrears received		250 19 0	
		2,290 14 0	
Add—Subscriptions paid in advance during current year		73 10 0	
			2,364 4 0
			£3,577 0 8

Institute of Mining and Mechanical Engineers. Cr.
July 31st, 1898.

June 30th, 1898.	£	s.	d.	£	s.	d.
By Printing and Stationery ...				151	6	6
„ Books for Library ...	30	11	9			
„ Prizes for Papers ...	11	11	0			
„ Incidental Expenses ...	49	14	7			
„ Postages ...	60	10	10			
„ Sundry Accounts ...	7	0	0			
„ Travelling Expenses ...	0	6	0			
„ Salaries ...	125	0	0			
„ Clerks' Wages ...	207	3	2			
„ Reporting ...	17	17	0			
„ Rent ...	58	17	2			
„ Rates and Taxes ...	20	3	5			
„ Insurance ...	8	6	11			
„ Furnishing and Repairs ...	7	7	3			
„ Coals, Gas, Water, and Electric Light ...	44	14	7			
„ Expenses of Meetings ...	20	14	5			
„ Explosives Committee, Rent ...	0	5	0			
„ General Index ...	17	16	6			
				687	19	7
By The Institution of Mining Engineers—						
Subscriptions ...	1,050	15	5			
Less—Amounts paid by Authors for Excerpts ...	6	5	6			
				1,044	9	11
				1,883	16	0
By Investments—						
Lambton & Co. Deposit Account ...				950	0	0
				2,833	16	0
By Balance at Bankers ...	674	2	5			
„ „ in Treasurer's hands ...	66	17	0			
Outstanding Amounts due for Authors' Excerpts ...	2	5	3			
				743	4	8

We have examined the above account with the books and vouchers relating thereto, and certify that, in our opinion, it is correct.

JOHN G. BENSON AND SON.
Chartered Accountants.

Newcastle-upon-Tyne,
August 5th, 1898.

	£3,577	0	8

DR. THE TREASURER IN ACCOUNT

	£	s.	d.	£	s.	d.
To 829 Members.						
1 „ not on printed list.						
830						
2 „ paid Life Composition				41	0	0
828						
37 of whom are Life Members.						
791 @ £2 2s.				1,661	2	0
To 98 Associate Members,						
7 of whom are Life Members.						
91 @ £2 2s.				191	2	0
To 91 Associates @ £1 1s.				95	11	0
To 45 Students						
1 Elected Associated Member						
44 @ £1 1s.				46	4	0
To 23 Subscribing Firms				90	6	0
To 75 New Members @ £2 2s.				157	10	0
To 1 New Member, paid Life Composition				24	0	0
To 2 New Associate Members, paid Life Composition ...				48	0	0
To 30 New Associate Members @ £2 2s.				63	0	0
To 15 New Associates @ £1 1s.				15	15	0
To 11 New Students @ £1 1s.				11	11	0
To 2 New Subscribing Firms				8	8	0
				2,453	9	0
To Arrears, as per Balance Sheet 1896-97	346	10	0			
Add—Arrears considered irrecoverable, but since paid ...	49	7	0			
	395	17	0			
Less—Struck off as irrecoverable—Arrears £67 4 0						
„ „ „ Current year 48 6 0	115	10	0			
				280	7	0
				2,733	16	0
To Subscriptions Paid in Advance				73	10	0
				£2,807	6	0

WITH SUBSCRIPTIONS, 1897-98. CR.

			PAID. £ s. d.	UNPAID. £ s. d.
By 690 Members, paid ...	... .	@ £2 2s.	1,449 0 0	......
By 96 " unpaid	... ...	@ £2 2s.	......	201 12 0
By 5 " dead ...	... ...	@ £2 2s.	......	10 10 0
791				
By 69 Associate Members, paid	... ...	@ £2 2s.	144 18 0	......
By 22 " " unpaid	... ...	@ £2 2s.	......	46 4 0
91				
By 79 Associates, paid ...	... ...	@ £1 1s.	82 19 0	......
By 12 " unpaid	... ...	@ £1 1s.	......	12 12 0
91				
By 35 Students, paid ...	... ...	@ £1 1s.	36 15 0	......
By 9 " unpaid	... ...	@ £1 1s.	......	9 9 0
44				
By 2 Subscribing Firms, paid	... ...		6 6 0	......
By 21 " unpaid	... ...		......	84 0 0
23				
By 75 New Members, paid	... .	@ £2 2s.	157 10 0	......
By 2 Members, paid Life Composition	... ...		41 0 0	......
By 1 New Member, paid Life Composition ...	... ...		21 0 0	......
By 30 New Associate Members, paid	...	@ £2 2s.	63 0 0	......
By 2 New Associate Members, paid Life Composition	...		48 0 0	......
By 15 New Associates, paid	... ...	@ £1 1s.	15 15 0	......
By 11 New Students, paid	... ...	@ £1 1s.	11 11 0	......
By 2 New Subscribing Firms, paid ...	.. ...		8 8 0	......
			2,089 2 0	364 7 0
Less—Struck off as irrecoverable ...	... ...		......	48 6 0
				316 1 0
By Arrears	... .		250 19 0	77 14 0
By Subscriptions paid in advance	... .		73 10 0	......
			2,413 11 0	393 15 0
				2,413 11 0
				£2,807 6 0

General Statement, June 30th, 1898.

Liabilities.

	£	s.	d.	£	s.	d.
Subscriptions paid in Advance during the year	73	10	0			
„ carried over from previous year	2	2	0			
				75	12	0
The Institution of Mining Engineers				96	2	9
Capital				9,448	15	5
				£9,620	10	2

We have examined the above accounts with the books, vouchers, and securities relating thereto, and certify that, in our opinion, it is correct. We have accepted the "Transactions and other Publications" as valued by your Officials.

JOHN G. BENSON AND SON,
Chartered Accountants.

Newcastle-upon-Tyne,
August 5th, 1898.

Assets.

	£	s.	d.	£	s.	d.
Balance of Account at Bankers	674	2	5			
„ in Treasurer's hands	66	17	0			
Outstanding amounts due for Authors' Excerpts	2	5	3			
				743	4	8
Arrears of Subscriptions				393	15	0
146 Shares in the Institute and Coal Trade Chambers Co., Ltd. (at cost)	3,130	0	0			
Investment with the Institute and Coal Trade Chambers Co., Ltd. (Mortgage)	1,400	0	0			
				4,530	0	0
Interest on ditto, half-year				24	10	0
(Of the above amount, £350 is due to Life Subscriptions Account, leaving £323 12s. not invested.)						
Deposit with Lambton & Co.				1,150	0	0
Value of Transactions and other Publications, as per Stock Account				579	0	6
Office Furniture and Fittings	450	0	0			
Books and Maps in Library	1,750	0	0			
				2,200	0	0
				£9,620	10	2

ALTERATION OF BYE-LAWS, Nos. 8, 9, 10, 11, 12, 14, 15, 16, 21 AND 39.

Mr. G. B. FORSTER proposed in the print of the proposed alterations of the Bye-laws, that the words "who shall himself sign the undertaking contained therein" should be inserted after the words "knowledge of candidate" in the first, second and third paragraphs of Bye-law 8. With these alterations, he proposed that the amended bye-laws Nos. 8, 9, 10, 11, 12, 14, 15, 16, 21 and 39 be approved.

Mr. THOS. DOUGLAS seconded the motion, which was unanimously adopted.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS.

The CHAIRMAN (Mr. G. May) moved, and Mr. G. B. FORSTER seconded, a resolution that the following gentlemen be elected as the representatives of the Institute on the Council of The Institution of Mining Engineers:—

Mr. HENRY ARMSTRONG.
Mr. WILLIAM ARMSTRONG.
Mr. HENRY AYTON.
Mr. R. DONALD BAIN.
Mr. T. W. BENSON.
Mr. BENNETT H. BROUGH.
Mr. WILLIAM COCHRANE.
Mr. G. B. FORSTER.
Mr. T. E. FORSTER.
Mr. JOHN GERRARD.
Mr. NATH. R. GRIFFITH.
Mr. W. F. HALL.
Mr. JEREMIAH HEAD.
Mr. ARCH. HOOD.
Mr. A. C. KAYLL.
Mr. HENRY LAWRENCE.
Sir WILLIAM THOMAS LEWIS, Bart.
Prof. HENRY LOUIS.
Mr. HENRY W. MARTIN.
Mr. GEORGE MAY.
Mr. C. A. MOREING.
Mr. JOHN MORISON.
Mr. HENRY PALMER.
Mr. JOHN RIDYARD.
Mr. A. R. SAWYER.
Mr. F. R. SIMPSON.
Mr. J. B. SIMPSON.
Mr. A. L. STEAVENSON.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. VICTOR MANUEL BRASCHI, Engineer and Contractor, Apartado 830, City of Mexico, Mexico.

Mr. MICHAEL CURRY, Colliery Manager, Edmondsley Colliery, Chester-le-Street.

Mr. THOMAS H. C. HOMERSHAM, Engineer, Vulcan Iron Works, Thornton Road, Bradford.

Mr. HERBERT LLOYD, Civil, Mining and Consulting Engineer, Engineering Offices, Middelburg, Transvaal, South Africa.

Mr. ARTHUR WALTER MENZIES, Mechanical Engineer and Surveyor, Menai Bank, Carnarvon.

Mr. EMIL LAURENCE OPPERMANN, Electrical Engineer, 7, St. Mildred's Court, London, E.C.

Mr. TREVOR FALCONER THOMAS, Mining Engineer, Llandaff Place, Cardiff.

ASSOCIATE MEMBERS—

Mr. TOM BOWER, P.O. Box 104, Kalgoorlie, Western Australia.

Mr. D. W. BRUNTON, Aspen, Colorado, U.S.A.

Mr. J. COATS, Rossland, British Columbia.

Mr. BENJAMIN DOUGLAS, c/o Union Steamship Company, Cape Town, South Africa.

Mr. JESSE GREGSON, Australian Agricultural Company, Newcastle, New South Wales.

Mr. J. MEIKLEJOHN, Oriental Hotel, Water Street, Vancouver, British Columbia.

Mr. PERCY CHARLES RICHES, Public Works Department, Norseman, Western Australia.

Mr. A. E. RITCHIE, 63, Queen Victoria Street, London, E.C.

Mr. ERLING EINAR THIIS, Prindsens Gade No. 4, Christiania, Norway.

Mr. CHARLES EDWARD TURNER, The Grange, Paradise Row, Stoke Newington, London, N.

ASSOCIATES—

Mr. THOMAS BELL, Under-manager, White Lea Colliery, Crook, R.S.O., Co. Durham.

Mr. JOSEPH FINNEY, Colliery Engineer, Elswick Collieries, Newcastle-upon-Tyne.

Mr. JAMES JOHNSON, Sinking Contractor, 4, Oswald Terrace, Castletown, Sunderland.

SUBSCRIBING FIRM—

THE HARTON COAL COMPANY, LIMITED (3), Harton Colliery, South Shields.

DISCUSSION UPON MR. T. G. LEE'S PAPER ON "EXPLOSIONS IN AIR-COMPRESSORS AND RECEIVERS."*

Mr. W. C. BLACKETT (Durham) said that until he read Mr. Lee's paper he thought that the use of oil in air-compressing cylinders was a thing of the past. He was surprized at the statement in the paper that they were unable to use soap and water. He had known air-compressors going for 20 years, during which time nothing but soap and water had been used, or really water and soap, because they did not even take the trouble to mix the soap with the water. A lump of soft soap was thrown into the water, which was injected by a force-pump in the form of spray so as to cool the air, and that was sufficient to lubricate the air-compressing cylinders. The fact that others had a difficulty in using soap and water

* *Trans. Inst. M.E.*, vol. xiv., page 554.

rather pointed to the suggestion that the pistons were probably not of the best construction for the purpose. At a colliery under his charge, the top had been taken off one of the pistons, and as an experiment it had been partly packed with hard manilla yarn, like an ordinary squirt-packing. This was last done 2 years ago, and it was still in good condition. They had no trouble with the water passing with the air into the mine and freezing at the exhaust-ports of the air-engines. What little trouble there was with ice, was overcome by injecting into the exhaust-openings a small driblet of water, and since then they had had no further trouble with ice.

Mr. HENRY LAWRENCE said that he had long been of opinion that soft soap and water was a sufficient, and the best lubricant for use in air-compressing cylinders. He found that it formed a fine skin on the inside of the air-cylinder. He thought that the explosion in the air-compressing cylinder was somewhat novel. They had an ignition in the air-compressing cylinder at Clifton colliery in 1895, and it would have warned him that an explosion would happen, and it actually did take place in 1897.

Mr. J. MORISON (Cramlington) stated that he read a paper upon the same subject in 1888,* and at that time he was of opinion that the so-called explosion was caused by the vapour of the oil which had become ignited. Now it seemed to him that, in the present case, neither in November, 1895, nor in May, 1897, was there any explosion in the air-receiver or in the air-compressing cylinders, and it appeared to him that the so-called explosions had been improperly attributed to the oil-vapour. He himself attributed them to oil-vapour in 1888, and he held the same view for a considerable time. But in this case and others which had come under his notice, it appeared that there had been a gradual accumulation of residue from the oil, and that this substance had ignited, and in fact created a huge fire in the pipes and air-receiver. At Clifton colliery, it seemed to him beyond doubt that there had been no explosion, but that a considerable fire had arisen in the air-receiver, from the combustion of the residue of the mineral oil which had accumulated in the air-pipes and air-receiver. It was quite clear from the evidence that there had not been an explosion of the oil-vapour. If a fire was developed rapidly, the air in the receiver and pipes would speedily acquire an increased volume, and would naturally escape at the safety-valves in the same way as any other accumulation of gases

* *Trans. N.E. Inst. M.E.*, vol. xxxviii., page 3.

would escape. All that happened, as described in the paper, appeared to be the simple result of a large fire in the pipes and air-receiver.

He had had considerable experience of air-compressing machinery, and could tell Mr. Blackett that although his particular circumstance might enable him to use soft soap and water, it was not by any means the universal experience. Many engineers had tried and abandoned the use of soft soap and water, because it was not suitable to their circumstances. He himself had tried it for a considerable time after the experience that he had had with mineral oil, and in his case the air-compressing cylinders were cut and grooved, and considerable trouble arose with the air-engines down the pit owing to the formation of ice in the exhaust-ports. Hemp did not appear to him to be a suitable packing for the piston of an air-compressor. He thought it would give rise either to considerable friction in working, or would allow of a leakage of air from one side of the piston to the other.

The author, in Table I.,* showed that the maximum indicated pressure in the air-cylinder was above the pressure in the air-receiver, to the extent of a minimum of 7 lbs. and a maximum of 19 lbs. per square inch. This excess of pressure clearly proved that the discharge-valves or air-pipes from the air-compressing cylinder were too small. He thought it had been fully demonstrated that the accumulations of the carbonaceous deposit in the pipes and air-receiver arose from the mineral oil; and he had no doubt that the preliminary fire was initiated in the restricted passage for the air through the valves and the pipes. A considerable number of experiments had been made in Germany with air-compressors,† and it was conclusively proved that the slide valve-ports between the air-cylinder, and the discharge-ports from the cylinders, if not of ample area, or if crooked, were speedily closed by deposits of the decomposed lubricant. The German authorities had issued suggestions which corresponded very much with the recommendations set forth in Mr. Lee's paper, and they recommended the use of oil of good quality, efficient cooling of narrow ports and valves, and an arrangement for a through draught in the air-receiver, in order to prevent accumulations of oil-vapour. The air-receivers should also be fitted with proper sludge-cocks in suitable positions, so that they might be cleared at adequate intervals.

Mr. W. C. BLACKETT said that, notwithstanding Mr. Morison's opinion, he still condemned the use of oil in air-compressors. The fact

* *Trans. Inst. M.E.*, vol. xiv., page 557. † *Ibid.*, vol. xiv., page 613.

that water and soft soap had not been found to suit some air-compressors did not, to his mind, point so much to the condemnation of water and soft soap as to the condemnation of the conditions, and the conditions should be made to fit the water and soap, and not the water and soap to fit the conditions. With all due deference to the last speaker, it did not follow that a packed piston was not a good one for use in an air-compressor, and probably the members would realize that when they began to put a large quantity of water into a cylinder they began to introduce conditions similar to that prevailing in an ordinary pump. No one, as a rule, attempted to pump water with ordinary pistons and rings. When an action similar to that of a pump was produced, and it was readily produced owing to the large quantity of water and soap in the cylinder, then they began to be successful in the use of soft soap and water. Anyone watching the motion of an air-compressor could see at once whether it was inhaling air in the return stroke. He was not experienced in the use of high pressures of air, but for ordinary working pressures he maintained that the use of oil was improper, and that soap and water was the only proper lubricant to use.

Mr. Henry Lawrence said that he understood Mr. Morison to state that there had been no explosion of an air-receiver. He (Mr. Lawrence) thought that if Mr. Morison would refer to Plates XLIII., XLIV., and XLV.* showing the condition of the air-receiver after the accident at Ryhope colliery, he would tell the members at once that there must have been some sort of an explosion.

Mr. J. Morison considered that an ignition of the deposit in the pipes and air-receiver might have occurred at Ryhope colliery, and an explosion followed, and if safety-valves were not large enough, and there was a big fire, this would undoubtedly occur.

Mr. H. Lawrence thought that if there was no explosion at Clifton colliery he agreed that it was due to the flame passing out of the safety-valves, and so relieving the pressure. The description of the engineman as to sparks and flames issuing out of the safety-valves and joints of the cylinders and pipes appeared to indicate extraordinary conditions.

Mr. W. C. Blackett suggested that, owing to circumstances, in one case combustion and in another case combustion amounting to explosion might occur.

* *Trans. N.E. Inst. M.E.*, vol. xxxvii.

Mr. J. MORISON said that he wanted to put clearly the difference between the formation of explosive gaseous mixtures in the air-receiver and the effect of intense heat expanding the air in the receiver, as the two phenomena were so different.

Mr. T. G. LEES, in replying to the discussion, wrote that his experience with soft soap and water for the lubrication of air-compressing cylinders led him to believe that good results might be obtained for slow speeds, but where the compressors were running up to 50 revolutions per minute, as at Clifton colliery, there was not sufficient lubricating properties in soft soap to keep the cylinders in good condition, and even if the quantity of solution was largely increased, the accumulation of residue required the frequent cleaning of the pistons and cylinders, so that its continued use was very objectionable, as explained in his paper. With regard to packing the air piston with manilla yarn as suggested by Mr. Blackett, this might be effective in some cases, but it was questionable if it would answer for cylinders of large diameter and running at high speeds. As to whether the incidents related were ignitions or explosions, Mr. J. Morison was probably right in saying that both were simply ignitions of residue from the oil which had accumulated in the air-pipes and receivers, but the writer had no doubt that much oil-vapour was given off and was fired, causing the joints to blow out and finding a speedy release by means of the safety valves on the air-receivers, otherwise an explosion of a dangerous character would have resulted.

DISCUSSION ON MR. PHILIP KIRKUP'S PAPER ON "THE MANUFACTURE OF FIRE-CLAY GOODS FROM THE UNDER-CLAYS OF THIN COAL-SEAMS."*

Mr. P. KIRKUP said that it was a difficult matter to judge from a chemical analysis of clay as to its value for any purpose. It was rather significant that in comparing analyses of raw fire-clay it always followed that the alumina and combined water bore more or less relative proportions, so that (indirectly) water in combination in any clay was a measure of its consistency, and in fact a measure of the "hydrated silicate of alumina," which was the basis of all true clays. The combined water practically disappeared on the clay being calcined, and the body or consistency was thereby much reduced.

Coke-oven bricks were usually made from a mixture of equal parts of ganister and fire-clay. But good coke-oven bricks without ganister could

* *Trans. Inst. M.E.*, vol. xv., page 45.

be made from ordinary fire-clay (containing not less than 10 per cent. of alumina) with a proper admixture of free silica in the shape of sand or pure post stone, taking care, of course, that the fire-clay became granular by being put through a riddle, with 16 to 36 apertures per square inch—and that it had sufficient consistency in working up.

In the use of the improved furnace, he might mention that the greater the heat required to burn any bricks the greater would be the economy, inasmuch as the improved furnace was fed with hot air instead of cold air.

Mr. A. L. Steavenson said Mr. Kirkup had given his attention to the temperature that fire-bricks would stand without fusing, but during late years in the erection of retort coke-ovens another quality was necessary, and that was—that the bricks should neither shrink nor swell under high temperature. The retort-oven had a large number of flues, and if the bricks shrank or swelled, the flues and the oven were destroyed.

Mr. Kirkup said that, in making bricks for use in coke-ovens, it was important that a strong siliceous clay should be used, but it must not be forgotten that there was a difference between free and combined silica. A brick made from a clay in which there was a large amount of free silica, when subjected to heat, as in coke-ovens or furnaces, would not contract, but actually expand. The ganister clay, referred to in Table I., containing 85 per cent. of silica and 7½ per cent. of alumina, with an admixture of about 25 per cent. of fire-clay, made an excellent brick for coke-oven purposes. The fire-clay was added so as to improve the consistency, or otherwise it would be impossible to mould and burn the goods.

The Chairman asked whether Mr. Kirkup had any experience of the use of bricks made from different classes of clay in retort coke-ovens, because if bricks expanded serious damage speedily occurred in the flues.

Mr. A. L. Steavenson asked for information as to the pressure that sanitary pipes would carry. He was going to carry a railway over some sewage-pipes, and could not find any information as to the pressure which they would sustain.

Mr. Kirkup said that he had no experience as to the manufacture of bricks suitable for use in the erection of retort coke-ovens. He only made the remark that bricks, made from fire-clay in which there was a large proportion of free silica, would have the minimum of contraction.

The following paper on the "Transvaal Coal-field," by Mr. William Peile, was taken as read :—

TRANSVAAL COAL-FIELD.

By WILLIAM PEILE.

Commencing in Cape Colony, and extending over the Orange Free State, parts of Natal, and Zululand, into the south-eastern portion of the Transvaal, is a vast spread of sandstone strata, containing coal-measures.

The coal-bearing sandstones or coal-measures are about 1,000 feet in thickness, with red sandstone-beds above, and sometimes below them. These beds may be described as horizontal, a striking characteristic feature of the country, accounting not only for the flat summits of the mountains, the sluggish and winding character of the streams, but also for the level table-land formation of the whole country.

The coal-measures have frequently been reduced in thickness by denudation, and pierced through by the upheaval of igneous rocks, or interfered with by the tilted beds belonging to a lower series ; as, for example, along the high ridge running east and west at Johannesburg, in which are the banket or gold-bearing conglomerates of the Rand. This ridge, at an elevation of about 5,600 feet above sea-level, forms the divide or watershed of the country, and the High Veld extends all the way to Ermelo, the eastern limit of the coal-field, where all the principal rivers in this part of the country have their sources (Fig. 1, Plate I.).

The Vaal river flows a little to the south, then in a westerly direction, parallel with the High Veld, to the Atlantic Ocean, and forms the southern boundary of the Transvaal. The Komatie, and other rivers to the east, flow into Delagoa Bay. The Olifants, and other rivers to the north—branches of the great Limpopo or Krokodil river—flow into the Indian Ocean.

The coal-measures comprise gravels, clays, coarse and fine grits, and dark and light sandstones, interstratified with carbonaceous and micaceous shales, with seams of coal.

Owing to the extensive denudation of the country, these measures have been reduced in the Transvaal to a thickness not exceeding 600 feet in some places. Fortunately, the coal-seams in the Transvaal are comprised in the lower part of the series, and throughout the eastern

part of the coal-field we have the seams often exposed, or outcropping on the breast of the hills, along the banks of the spruits; often denuded altogether in the valleys, and at shallow depths, even on the High Veld.

In the western part of the coal-field, along both sides of the ridge, but principally to the south, overlying unconformably the upturned beds of the older series, and subject to their irregularities as well as to denudation, the coal-measures occur in patches, shallow lagoons, or lenticular deposits, covered up with *débris* of comparatively recent formation.

The seams vary in thickness and extent. At the Great Eastern colliery, near Springs, there is a succession of coal-beds 75 feet in thickness, and in a short distance these beds are divided into three or more seams. With only a series of overlying sandstone beds, from the information he has obtained, the writer finds it impossible to satisfactorily correlate them with the seams in the eastern portion of the field.

The coal from these deposits is inferior in quality, splinty and dull in appearance, and contains a high percentage of sulphur and ash; but the situation is convenient for railway-transport to the gold-mines along the Rand.

The sections of strata (Appendix, and Fig. 2, Plate II.) are all taken in the Middleburg district, within the strip of ground between Brugspruit and Witbank stations, on the Delagoa Bay branch of the Netherlands railway. Six distinct seams of coal have been found within a depth of 172 feet, which are marked Nos. 1 to 6, and as No. 5 is the most important seam, all of them have been plotted to that seam as a datum-line. The Blauwkrantz section contains a total thickness of 58 feet of coal, at a depth of 200 feet; and the Schoongezicht borehole proves nearly 180 feet of strata below the bottom seam, through 42 feet of conglomerate and into red sandstone-beds. These several seams may be recognized outcropping in many places over an area exceeding 80 miles square, extending diagonally south-east from Balmoral to Ermelo, and south-west from Belfast in the direction of Heidelberg.

The coal-field may be comprised within a line south of Krugersdorp to a similar line east of Ermelo, about 170 miles in length by 120 miles in width, covering an area of about 20,000 square miles.

The age of this coal-bearing formation has created a considerable amount of geological interest, and it does not yet appear that geologists have determined whether it belongs to the Carboniferous or a more recent period; but as the country is developed, more information, and the discovery of more fossils, will possibly enable the question to be settled.

Owing to the shallow depth of the overlying strata, and to the seams so frequently outcropping, the entire coal-field appears to be free from explosive gas. The formation is also very free from faults, but is subject to intrusions of igneous dykes, with overflows and float-boulders of basalt and diorite spread over the surface, altering the nature of the strata and coal-seams in their immediate vicinity; often changing bituminous seams into semi-bituminous and anthracitic, by driving off the volatile matter in the coal, but not disturbing the general horizontality of the beds. Associated with these intrusions, deposits of magnetite and a softer sedimentary, and sometimes stratified iron-ore, are occasionally met with, perforating and overlying the coal-measures, whilst large areas of the surface are covered with siliceous iron-ore of a pisolitic appearance, sometimes varying to over 2 feet in thickness and generally overlying the coarse gritty sandstone beds on the High Veld, associated with the upper part of the coal-bearing strata. This ore is known throughout the country as *old klip*, and has often been used for rough building purposes. It appears, along with the hard grit, to have withstood the denudation, or overwhelming force of water that has swept the overlying strata away and so protected the coal-seams, or it may have been formed from the sediment existing in the waters when the denudation of the country ceased and so was left on the high ground, the oxide of iron cementing the sand into the present mass, notwithstanding all later climatic influences.

Peculiar to South Africa is the occurrence all over the country of numerous circular lakes or depressions, sometimes of large extent, locally known as *pans*, the origin of which the writer had never heard explained. Having regard to the overwhelming flow of water that at one period overran the country, it appears that obstructions from hardened or other strata would cause whirlpools and so wash away the circular areas before the obstructions were overcome, as these pans are frequently found near dykes, whose hardening tendency is evident. At all events the writer had seen no evidence of the bending down of the strata around the circumference, as would be the case if the pans were formed by depressions in the surface, and it would be difficult to account for such depressions on the edges of upturned strata, where the pans are also to be found.

Regarding the undulating character of the surface, it appears to be due to denudation eroding away the beds, and also to the unequal upheaval of the continent through upflows of recent igneous matter. Horizontal as the strata appear, they are nevertheless often locally

undulating, and the writer noticed in the district south of Middleburg that the beds have a regular but slight dip to the south-east.

The Kromkranz farm, in the Carolina district, is interesting from a geological point of view, the coal-formation being denuded over the western portion, leaving the grits with the coal-seams standing out cliff-like, 50 to 60 feet high, and water-worn or under-cut along the base in a wonderful manner, showing what a vast and powerful erosion of the country occurred at one period for a long time.

A picked sample of old klip contained 39·82 per cent. of metallic iron, and 22·82 per cent. of silica. As the average content will not exceed 25 per cent. of metallic iron, it is therefore too high in silica and too low in iron to be of commercial use in the blast-furnace.

The magnetite is a splendid sample of iron-ore: very hard and refractory, but used along with the sedimentary ore, it will work well in the furnace. It is highly magnetic, affects the compass needle, and small fragments will attach themselves to the pick just as steel splinters stick to a magnet. It contains 66·23 per cent. of metallic iron. The sedimentary ore contains by analysis 63·38 per cent. of metallic iron (with a trace of phosphoric acid), and both ores have been pronounced suitable for making bessemer pig-iron.

The writer has occasionally seen the sedimentary ore outcropping. The following is a section:—

	Ft.	Ins.
Soil	0	6
Seamy iron-ore	0	8
Parting	...	
Good iron-ore	1	8
Parting	...	
Soft iron-ore, mixed with clay	1	0
Parting	...	
Bottom iron-ore, good	1	8
Total	4	4

The extent of these deposits of iron-ore has not been proved, but there is abundance of good iron-ore, coking coal, limestone, silica, possibly suitable fire-clay, and building-stone in the Transvaal, suitable for the manufacture of iron and steel when the time comes for the erection of smelting-plants and iron and steel-works, whether independently or under a concession from the government of the South African Republic.

The plan of the coal-field (Fig. 1, Plate I.) shows the position of the mines and boreholes. The probable extent of the coal-area, as proved up to the present time, is contained within the shaded black lines, defined partly from observation, from published maps, or left incomplete.

The sections of strata (Appendix, and Fig. 2, Plate II.) are from boreholes made in the small area between Brugspruit and Witbank; Blauwkranz and Landaus boreholes were put down on high ground and show all the six seams, the others only show No. 5 seam, or Nos. 5 and 6 when deep enough, whilst close to, possibly on, the same farm, the country is denuded to below No. 6 seam, and contains no coal. It is therefore important in selecting coal-farms to have a knowledge of the stratification of the coal-bearing beds. The farms vary in size, but mostly comprise an area of 8,000 to 10,000 acres. The seams vary in thickness and in quality, as may be expected, and appear to be better in quality, more bituminous and cleaner, towards the eastern limit; but the writer is not aware of any good proof of the strata by pits or boreholes. Only the outcrops of the seams have occasionally been opened, and they are rather difficult to correlate as so little of the strata—on account of their horizontality—is exposed.

The comparison of the qualities of the coal from three districts is shown in the following table:—

Sample.	Near Brugspruit. No. 1.	Near Brugspruit. No. 2.	Near Bethel. No. 3.	Near Springs. No. 4.
Moisture	0·15	0·80	0·30	0·57
Volatile matter ...	24·86	27·80	41·23	14·10
Fixed carbon ...	64·25	64·10	52·16	63·00
Ash	10·67	6·50	6·31	22·00
Sulphur	0·07	0·80	trace	—
	100·00	100·00	100·00	99·67
Yielding coke ...	74·97	70·80	58·47	—

The first sample of coal will evaporate 12·7 pounds of water per pound of fuel.

Taking the direction of the Netherlands railway from Pretoria towards Delagoa Bay (Fig. 1, Plate I.), there is a very undulating but rising gradient to Belfast, the extreme north-eastern limit of the coal-field and highest point in the Transvaal, and then the gradient rapidly falls to the coast. On the northern side of the railway, between Pretoria and Bronkhorstspruit, there are various patches of coal overlying and between wavy upheavals of granite. At Bronkhorstspruit, the coal was found to be poor in quality, and working has ceased. Better coal is found north of Pretoria. Watervaal is being worked, and Honingnest and others are likely to be worked when the railway, now being constructed to Pietersburg, is opened for traffic.

In the neighbourhood of Bronkhorstspruit, and probably also in the direction of Middleburg, amongst patches of overlying or altogether denuded coal-measures, recent discoveries of diamantiferous ground with diamonds, etc., have changed the character of many of the farms from

indifferent coal-farms to diamond-farms, and high prices are said to have been paid for some of them; whilst veins of copper and other minerals have recently been discovered in the same neighbourhood, but their value has not yet been proved, as far as the writer can learn. Possibly, in the course of time, other parts of the series underlying the coal-measures will be proved, and are not unlikely to reward research and development.

At Balmoral, on the north side, the Douglas colliery is working a patch of coal on a hill-top, about 12 feet in thickness, with probably another bed lying below untouched; the rest of the seam has been denuded all round, exposing a great thickness of red sandstones that would possibly be Devonian, if the coal-measures are Carboniferous.

On the south side of the railway, No. 5 seam is being opened up on Honingkrantz and Balmoral; and, further south, one or more seams have been worked at Holfontein, Straffontein, and other places, the coal being transported to railway by ox-waggon; at the present moment, however, all these collieries, except Douglas, are standing.

The railway crosses the boundary of the coal-field just before it reaches Brugspruit, and passes through the most important district yet explored, for about 13 miles, until the seams are all denuded again by the Olifants river before Middleburg is reached.

Excellent coke has been made at the Maggie mine and at the Home coal-mine adjoining.

The strata given in the sections (Appendix, and Plate II.) accompanying this paper correspond with the measures to the south, along Steenkool Spruit, where some good coal has been proved, and extend all the way to Carolina and Ermelo.

No. 1 seam throughout is of a semi-bituminous character, sometimes like an anthracite coal.

Nos. 2 and 4 seams are usually thin.

No. 3 seam is variable.

The upper part of No. 5 seam is of a splinty character; it has been opened out in many places, but is most vigorously worked at present in the neighbourhood of Witbank, where the bottom coal is excellent, equal in every way to the best British coal. On Blesboklaagte, adjoining Witbank, it was proved by a borehole to be 20 feet in thickness, and the bottom coal is 11 feet 6 inches thick.

No. 6 seam is said to be of good quality; it averages from 3 to 4 feet in thickness, but has not been worked, except on the Driefontein farm.

The strip of coal on the north side of the railway from Middleburg to Belfast is poor in quality, doubtless owing to the proximity of granite

along the northern boundary or limit of the coal-field, but the quality improves to the south. Near Belfast, on Paardeplaats, a colliery belonging to the Transvaal Consolidated Coal-mines Company, Limited, has been opened up on the No. 5 seam, from 12 to 15 feet in thickness, and an average output of 100 tons per day is transported by ox-waggon to the Belfast station. The coal is of better quality than nearer Middleburg, on the northern side of the railway, and the output will no doubt be increased when the colliery is connected to the main line with a branch-railway.

Following round the coal-field towards Carolina, the measures all appear thinner, with quartzite and conglomerate overlying the granite, and cut up frequently by basalt dykes running in a north-easterly direction.

Near Ermelo, a bed of oil-shale has been discovered, and it will probably be worked.

The writer has not explored the country between Ermelo and Bethel, but on the southern side there are no important collieries except the Fortuna, working a seam from 8 to 9 feet in thickness, at a depth of only 45 feet, belonging to a lenticular deposit. The seam appears to correspond with No. 5 seam, the upper 4 feet being splinty in quality, and the lower 4 feet is a good bituminous coal. It is dipping to the north-east about 3 inches to the yard, and will probably become flatter and rise again. A borehole would further prove the strata, and possibly the seam now being worked may then be correlated with certainty.

Passing a group of small collieries on the south side of Heidelberg (the Perseverance, Platkoppe, Transvaal, and Oceana), all working different sections of outlying coal, and handicapped by the cost of transport from 8 to 12 miles by ox-waggon to Heidelberg, we come to the important colliery district of Springs, 32 miles from Johannesburg. Here is a group of collieries fitted up with modern plant, including water-tube boilers, winding and hauling machinery, with elaborate screening, separating and picking arrangements adapted to treat and bag the mixed and splinty varieties of coal up to 1,000 to 1,500 tons per day. These collieries include Springs, Cassel, Great Eastern, Clydesdale, East Rand Coal and Gold, De Rietfontein, Tyne Valley, and, further west, Central, Brakpan, Rand and Apex, with three or four older and less important collieries at Boksburg, including Good Hope, South Wales and Wishaw collieries, all working lenticular deposits of coal, as before described.

On the frontier, at Vereeniging, on both sides of the Vaal River, but

principally in the Orange Free State, are the important Vaal River collieries belonging to Messrs. Lewis and Marks. Great difficulty was experienced in sinking the Cornelia pit through the surface-clay and quicksands, steel and cast-iron tubing having to be used to a depth of nearly 130 feet. Eventually four seams of coal were passed through, and the quartzite was reached at a depth of about 450 feet. The section is as follows:—

	Thickness of Strata.		Depth from Surface.	
Description of Strata.	Ft.	Ins.	Ft.	Ins.
No. 1 Coal-seam	1	9	324	0
No. 2 Coal-seam	6	0	352	0
No. 3 Coal-seam, inferior	22	0	420	0
No. 4 Coal-seam, good	13	0	442	0

No. 4 seam has been chiefly worked, and a good output produced: it has the character of being a good coal, and very hard to work.

Further westward, a series of beds of coal, about 200 feet in thickness, have recently been proved by a borehole on the farm of Syferfontein, about 17 miles south of Krugersdorp, belonging to the Syferfontein and Gold Estates Company, Limited. Coal was first found at a depth of 313 feet, and continued to a depth of 530 feet when dolomite was struck. An average analysis of the coal between 313 and 390 feet gave:—

Ash	21·1	
Volatile matter	44·0	
Fixed carbon	34·9	
	——	100·0

whilst one bed at a depth of 513 feet, 3 feet 8 inches in thickness, gave:—

Ash	7·9	
Volatile matter	48·9	
Fixed carbon	43·2	
	——	100·0

Calorific power, 12·6 pounds of water per pound of fuel.

This borehole is at the most westerly point where coal has been proved, and how much further the formation extends it is impossible to say.

The seams are for the most part easily accessible (except, possibly, in the western part of the coal-field), with good roofs, practically no timber being required, and little or no water to pump. Natural ventilation is usually relied upon, upcast pits being put down when extensions underground require them, and the pits being shallow, except round the shaft, small pillars are left.

Bagging nearly all the coal raised is a very troublesome, as well as a costly operation. It appears that the Netherlands Railway Company will only allow siding-connexions within the station-limits, and very few of the

gold-mines (as yet) are so connected. One ton of coal equals 2,000 lbs., and is bagged in 200 lbs. lots. A bag costs 5d., and lasts, on an average, three full journeys, so bags alone cost 1s. 4½d. per ton, and the extra labour employed, including losses and repairs, brings the cost up to nearly 2s. per ton. Several varieties of round and nut coal are usually made, including steam, gas, smithy, household, nuts, and peas. Native labour, at a cost of less than £1 per week, including monthly wage and keep, is employed wherever possible, under the supervision of an experienced miner, who usually superintends about 35 boys, seeing that they get through the work assigned to them. The cost of working, including bags and bagging, varies according to output and standing charges, from 4s. 6d. to 6s. 6d. per ton, 5s. 6d. being looked upon as an average cost with a fairly large output. Railway-charges on coal and material are excessive, and a serious drawback to the development of the Rand gold-mines, and of many collieries that have been opened out, particularly those that have ox-waggon charges to pay as well. The Netherlands Railway Company insist upon supplying all the trucks in use. They carry 11 tons of bagged coal each, and if a truck is very slightly overloaded the collieries are promptly fined. A charge of 2s. per waggon is made for taking out of sidings, and different rates per ton per mile according to distance :

		Miles.	Cost. s.	Cost. d.	Rate per Ton per Mile. d.
From Brugspruit to Johannesburg	...	115	12	6	1·30
From Springs to Johannesburg ...	...	32	6	6	2·44

From January 1st, 1898, 20 per cent. has been allowed off the above charges, reducing them to 10s. and 5s. 2d. per ton respectively. No credit is given, cash must be paid down, or a credit balance kept with the railway company.

Witbank is 275 miles from Delagoa Bay, and the railway company take coal, if they have empty waggons returning, at a through rate of 10s. 4d. per ton. The natural situation and facilities for cheaply constructing loading depots for shipment of coal to the Far East and other parts of the world, including the bunkering of steamers trading and calling along the coast, with the development of trade throughout the country, is practically certain before long to make Delagoa harbour another outlet for the coal from Middleburg, with South Wales coal selling on the wharf at 45s. per ton. The Middleburg district already competes favourably with Springs, realizing at Johannesburg about 23s. per ton, against 17s. 6d., thus compensating for the extra cost of transport, and leaving a fair margin for profit wherever collieries are opened out with good coal, convenient to the Netherlands railway.

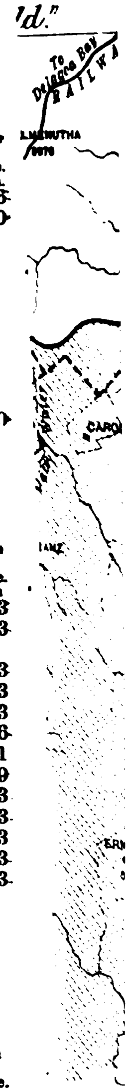
There is a royalty charge, payable to government, of 1 per cent. on the value of coal sold at the pit.

Many coal-farms have been taken up or purchased within recent years, either out and out, for coal-rights only, or for all mineral rights. The development of many of them will depend upon the construction of railways, the prosperity of the country, and the increased demand for coal by reason of the sinking and development of the deep-level gold-mines along the Rand, and the shipping trade with Delagoa Bay.

APPENDIX.

No. 1.—No. 3 Borehole, at Blauwkranz, near Brugspruit, for the Anglo-French Company, 1897.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Sandy soil	20	0	20	0
2	Blue limestone (?) ...	35	0	55	0
3	Hard red sandstone ...	3	0	58	0
4	Blue limestone (?) ...	1	0	59	0
5	White sandstone ...	18	0	77	0
6	Hard grey sandstone	23	0	100	0
7	Sandstone and shale ...	38	0	138	0
8	Hard shale	4	0	142	0
9	Shale	2	0	144	0
10	Grey sandstone ...	16	0	160	0
11	Sandstone and shale ...	12	0	172	0
12	Hard fine sandstone ...	18	0	190	0
13	Dark sandstone ...	12	0	202	0
14	Sandstone and shale ...	3	0	205	0
	No. 1 Coal-seam— (Ft. In.)				
15	**COAL** ... 1 3				
16	Shale ... 3 9				
17	**COAL** ... 5 6				
		10	6	215	6
18	Sandy shale	3	6	219	0
19	Shale	21	0	240	0
20	Coarse grey sandstone	7	0	247	0
21	Shale	0	6	247	6
22	Grey sandstone ...	3	6	251	0
	No. 2 Coal-seam—				
23	**COAL**	2	6	253	6
24	Hard grey sandstone	3	6	257	0
	No. 3 Coal-seam—				
25	**COAL** (no details given)	24	0	281	0
26	Dark sandstone ...	19	0	300	0
	No. 4 Coal-seam—				
27	**COAL**	0	6	300	6
28	Dark sandstone ...	3	0	303	6
29	Sandy shale	14	0	317	6
30	Shale	8	0	325	6
31	Sandy shale	15	0	340	6
	No. 5 Coal-seam— (Ft. In.)				
32	**COAL** ... 10 0				
33	Shale ... 0 6				
34	Sandstone ... 1 6				
35	**COAL** ... 8 0				
		20	0	360	6
36	Sandstone	13	6	374	0
	No. 6 Coal-seam—				
37	**COAL**	4	3	378	3
38	Conglomerate sandstone	34	3	412	6
39	Dark fine sandstone ...	25	0	437	6
40	Hard shaley slate ...	25	0	462	6
41	Broken slate	5	0	467	6
42	Hard slate	6	0	473	6
43	Gritty slate	2	0	475	6
44	Slate	12	0	487	6



No. 2.—No. 1 Pit, at Elandsfontein, near Brugspruit, Anglo-French Company.

No.	Description of Strata.	Seam Ft.	Seam In.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Red soil			5	0	5	0
2	Hard soil			4	0	9	0
3	Yellow clay			23	0	32	0
4	Coarse sandstone ...			2	0	34	0
5	Yellow clay			0	9	34	9
6	Red sandstone ...			0	6	35	3
7	Yellow clay			2	9	38	0
8	Yellow sandy clay ...			4	0	42	0
9	Black clay			2	6	44	6
10	Clay and shale ...			5	6	50	0
11	Dark shale			6	0	56	0
12	Red sandstone ...			1	0	57	0
13	Hard dark grey shale.			10	0	67	0
14	Dark sandstone ...			2	6	69	6
15	Grey sandstone ...			2	6	72	0
	No. 5 Coal-seam—						
16	**COAL** ...	1	6				
17	Dark shale ...	0	6				
18	**COAL**, shaley	1	5				
19	**COAL**, shaley	1	7				
20	**COAL**, shaley	1	0				
21	**COAL**, shaley	3	2				
22	**COAL** ...	12	10				
				22	0	94	0

No. 3.—No. 1 Trial Pit and Borehole at Schoongezicht, near Brugspruit, 1897.

No.	Description of Strata.	Seam Ft.	Seam In.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil			7	0	7	0
2	Sandy grit			17	0	24	0
3	Sand			0	6	24	6
4	Sandy grit			11	6	36	0
5	Clay shale			4	0	40	0
6	Carbonaceous shale ...			11	6	51	6
7	Micaceous shale ...			3	0	54	6
8	Carbonaceous shale ...			8	6	63	0
	No. 5 Coal-seam—						
9	**COAL** ...	0	6				
10	Shale with clay bands	1	6				
11	Shale ...	1	0				
12	**COAL** ...	1	0				
13	Shale ...	0	3				
14	**COAL** ...	15	0				
				19	3	82	3
15	Coarse grit			19	0	101	3
16	Shale			4	0	105	3
	No. 6 Coal-seam—						
17	**COAL**			3	0	108	3
18	Shale			2	0	110	3
19	Grit and conglomerate			5	0	115	3
20	Red sandstone ...			0	3	115	6
21	Gritty conglomerate			1	7	117	1
22	Sandy grit and shale			5	8	122	9
23	Coarse grit			17	6	140	3
24	Fine white sandstone			60	0	200	3
25	Dark grey shale ...			47	0	247	3
26	Conglomerate ...			42	0	289	3
27	Coarse red sandstone			2	0	291	3

No. 4.—No. 2 Borehole, at Klipfontein, near Brugspruit, for Landaus Transvaal Colliery Company.

No.	Description of Strata.	Seam Ft.	Seam In.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil			4	6	4	6
2	Gravel...			1	0	5	6
3	Soft white sandstone			8	6	14	0
4	Soft brown sandstone			27	0	41	0
5	Sandstone and shale...			45	9	86	9
	No. 1 Coal-seam—						
6	**COAL**			7	0	93	9
7	Shale			5	11	99	8
8	Sandstone			0	4	100	0
9	Shale			0	6	100	6
10	Sandstone			4	0	104	6
11	Grey shale			4	0	108	6
12	Black shale			16	6	125	0
	No. 2 Coal-seam—						
13	**COAL**			0	6	125	6
14	Conglomerate grits ...			1	6	127	0
15	Sandstone			1	0	128	0
16	Shale			0	6	128	6
	No. 3 Coal-seam—						
17	**COAL** ...	0	6				
18	Shale ...	1	4				
19	**COAL** ...	0	8				
20	Shale ...	1	0				
21	**COAL** ...	1	2				
22	Shale ...	0	6				
23	**COAL** ...	1	7				
24	Shale ...	0	3				
25	**COAL** ...	6	0				
26	Shale ...	2	0				
27	**COAL** ...	7	6				
				22	6	151	0

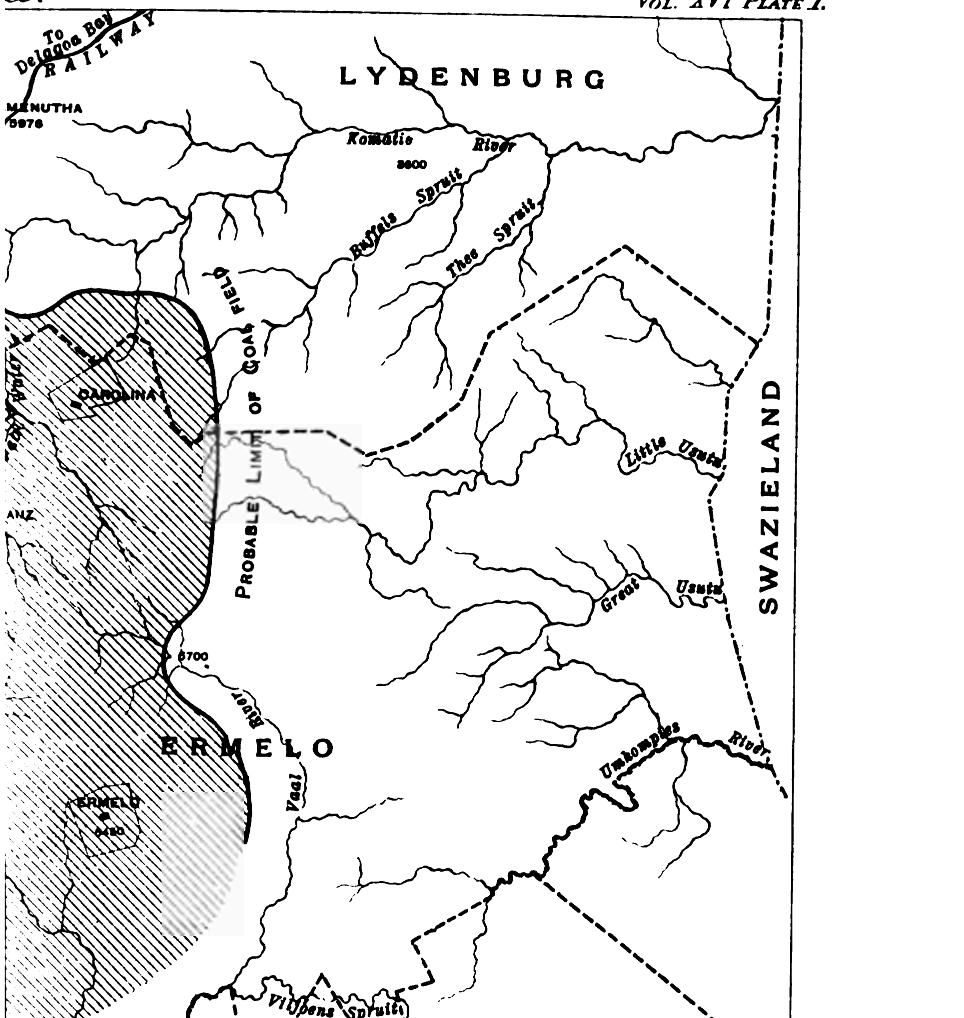

To Delagoa Bay
RAILWAY
LYDENBURG
Komatie River
3600
Buffels Spruit
Thee Spruit
PROBABLE LIMIT OF COAL FIELD
CAROLINA
SWAZIELAND
Little Usutu
Great Usutu
5700
Vaal River
ERMELO
ERMELO
5450
Umkompies River
Vilipens Spruit

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FIG. 2.

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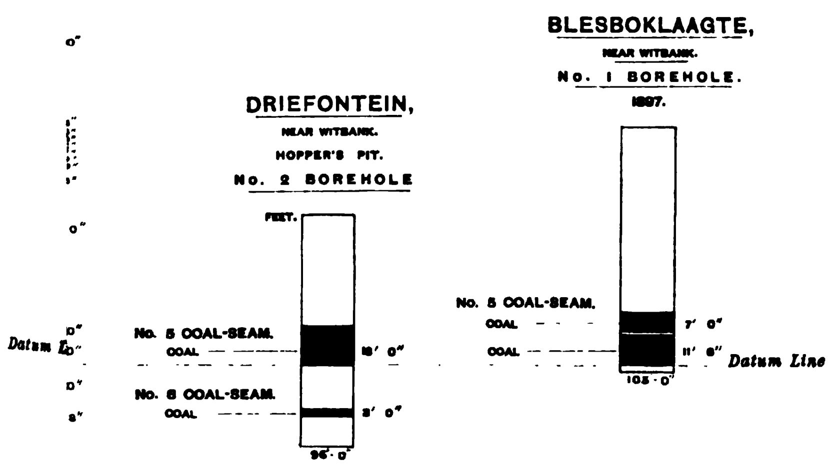


Scale, 80 Feet to 1 Inch.

No. 4.—*Continued.*

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
28	Shale	2	6	153	6
29	Conglomerate ...	5	0	158	6
30	Gritty conglomerate	10	0	168	6
31	Grey shale	1	0	169	6
	No. 4 Coal-seam—				
32	**COAL**	1	0	170	6
33	Shale	1	0	171	6
34	Grits	7	0	178	6
35	Sandstone and grits...	5	0	183	6
36	Grey shale	2	0	185	6
37	Dark shale	22	6	208	0
38	Grit	0	3	208	3
	No. 5 Coal-seam— (Ft. In.)				
39	**COAL**, semi-bituminous 7 0				
40	**COAL**, bright 9 10				
	——	16	10	225	1
41	Sandstone and shale	2	2	227	3
42	Conglomerate ...	4	6	231	9
43	Gritty sandstone ...	0	10	232	7
44	Shale	0	2	232	9
45	**COAL**	3	10	236	7
46	Shale	0	4	236	11
47	Gritty sandstone ...	10	0	246	11
48	Conglomerate ...	1	0	247	11
	No. 6 Coal-seam—				
49	**COAL**	3	8	251	7
50	Gritty sandstone ...	0	4	251	11
51	Conglomerate ...	—		—	

No. 5.—No. 2 Borehole at Driefontein, near Witbank, Hopper's Pit.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Gravel and clay ...	12	6	12	6
2	Soft sandstone ...	8	0	20	6
3	Shale	21	6	42	0
4	Sandstone	2	0	44	0
5	Shale	2	0	46	0
	No. 5 Coal-seam—				
6	**COAL**	16	0	62	0
7	Shale	0	6	62	6
8	Quartzite	1	0	63	6
9	Dark sandstone ...	5	0	68	6
10	Conglomerate ...	2	3	70	9
11	Shale	0	3	71	0
12	Conglomerate ...	2	6	73	6
13	Shale	0	6	74	0
14	Rough sandstone ...	2	6	76	6
15	Dark sandstone ...	2	6	79	0
16	Fine sandstone ...	2	0	81	0
	No. 6 Coal-seam—				
17	**COAL**	3	0	84	0
18	Shale and sandstone...	4	0	88	0
19	Reef	7	0	95	0
20	Shale	0	6	95	6
21	Light sandstone ...	0	6	96	0

No. 6.—No. 1 Borehole, Blesboklaagte, near Witbank, 1897.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil	4	0	4	0
2	Sand and gravel ...	6	0	10	0
3	Coarse grit	4	0	14	0
4	Hard dry clay ...	8	0	22	0
5	Coarse grit	33	0	55	0
6	Micaceous shale and sandstone	7	0	62	0
7	Shale	16	6	78	6
8	Sandstone	0	6	79	0
	No 5 Coal-seam— (Ft. In.)				
9	**COAL** ... 7 0				
10	**COAL**, splinty 1 6				
11	**COAL** ... 11 6				
	——	20	0	99	0
12	Shale	2	0	101	0
13	Grit	2	0	103	0

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

Held in the Wood Memorial Hall, Newcastle-upon-Tyne, October 8th, 1898.

Mr. WILLIAM ARMSTRONG, President, in the Chair.

The Secretary read the minutes of the last General Meeting, and reported the proceedings of the Council at their meeting on September 30th and on that day, and of the Council of The Institution of Mining Engineers.

The following gentlemen were elected, having been previously nominated :—

Members—

Mr. Harry Walton Appleby, Electrical and Mechanical Engineer, Trafalgar Works, Bradford, Yorkshire.

Mr. Archibald Duncan Bailey, Mining Engineer, c/o Señor Don Carlos Wagner, Arequipa, Peru.

Mr. David W. Brunton, Mining Engineer, Denver, Colorado, U.S.A.

Mr. Henry Alexander Judd, Mining Engineer, Lake View South Gold-mine, Kalgoorlie, Western Australia.

Mr. Robert Tennent, Inspector of Mines, Westport, New Zealand.

Mr. George Verney, Mining Engineer, Doubovais, Balka Krivoi, Russia.

Mr. Ernest Ludwig Adolph Weinberg, Mining and Metallurgical Engineer, Aldershot, Queensland.

Associate Members—

Mr. T. Owen Davies, Norseman Gold-mines, Limited, Norseman, Dundas Gold-fields, Western Australia.

Mr. Minett Edward Frames, P.O. Box 3517, Johannesburg, Transvaal.

Mr. George F. Harris, Birkbeck Institute, Bream's Buildings, London.

Mr. J. Hoffman, Fairview, Didsbury, Manchester.

Mr. Courtenay de Kalb, The School of Mining, Kingston, Ontario, Canada.

Mr. John William Murphy, Umaria Government Colliery, C.P., India.

Associates—

Mr. James Beckett, Deputy-overman, 57, Pine Street, Teams, Gateshead-upon-Tyne.

Mr. George Emmerson, Assistant-manager, Brandon Colliery, near Durham

Mr. William Heslop, Deputy, Hunwick, Willington, Durham.

STUDENTS—

Mr. FRANK KENDALL BORROW, Mining Student, Bekesbourne, Canterbury.

Mr. HUGH M. EDDOWES, Mining Student, College Court, Shrewsbury.

Mr. ALAN LEONARD STAPYLTON GREENWELL, Mining Student, South Durham Colliery, Eldon, Bishop Auckland.

Mr. FREDERIC THOMAS MARLEY, Mining Student, Hebburn Colliery, Newcastle-upon-Tyne.

Mr. ROBERT RAMSAY, Mining Student, Dunston Colliery, near Gateshead-upon-Tyne.

Mr. WILLIAM STEWART, Mining Student, Milnthorp House, Sandal, Wakefield.

DISCUSSION OF MR. W. MERIVALE'S PAPER ON "OCCURRENCES AND MINING OF MANJAK IN BARBADOS, WEST INDIES."*

Mr. W. MERIVALE (Barbados) wrote that Prof. H. Louis' description of the occurrence of bitumen "in streaks, pockets and veins, in certain horizons, as though the bitumen in a plastic state had filled up all the cracks and fissures," was a very good description of the occurrence of the manjak variety of bitumen in Barbados. There is a very good diagram in Prof. A. H. Green's *Physical Geology*, reproduced in Fig. 1, which is exactly the sort of section, dip and all, that be found in the manjak veins. If Mr. Cochrane will imagine a slip along the line marked "flat," he will see how the whole of the upper part of the vein may be carried along with the country hundreds of feet away. Miners working this carried-away portion will soon come to an end of their mineral, and will say, as they all have said here, that

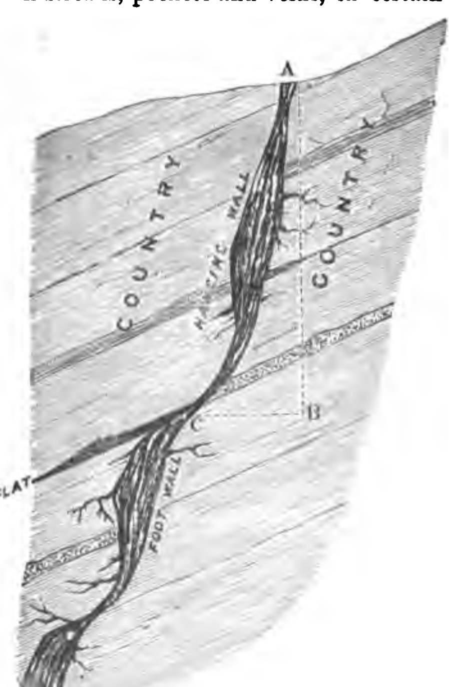


FIG. 1.—SECTION ACROSS A LODE.†

* *Trans. Inst. M.E.*, vol. xiv., page 539.

† Reproduced from *Geology, Part I., Physical Geology*, by Prof A. H. Green, 1882, Fig. 189, page 551.

it only occurs in pockets. Obviously, what is then required is to study the geology of the country, and find how far the slip has travelled; the rest of the vein should be found at the starting-point. This is certainly not an easy thing to do in this curiously contorted island. It fortunately happens that there have been no slips in the neighbourhood of his mines.

Sir Archibald Geikie's *Text Book of Geology* gives a diagrammatic section, reproduced in Fig. 2. Prof. H. Louis will see the writer's idea of the immediate origin of manjak in this illustration, that is a vast mass finding its way up through the lines of least resistance. Asphalt can hardly be supposed to have been formed *in situ*, as it is obviously an intrusive mineral. The slickensides on the walls of the fissures which it fills are sufficient of themselves to prove this opinion. If it was not formed *in situ* it must have come from somewhere. The ques-

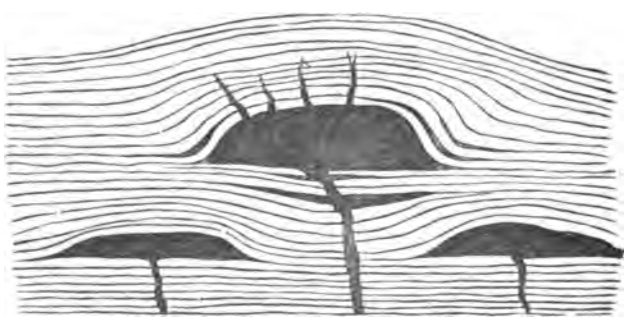


FIG. 2.—IDEAL SECTION OF THREE LACCOLITES, after Mr. G. K. Gilbert.*

tion to be answered here is not where did it come from, but how did it come? An enormous force must have been employed to thrust it up. We are dealing in large quantities: nothing less than the shrinking of the crust of the earth, which made the fissures, can have filled them with asphalt. From Utah to Barbados, we find these fissures having the same strike, filled with the same material. Can it be a small quantity? Can the source which was tapped to fill them be trifling in quantity? Why is it that the asphalt in the Trinidad pitch-lake continues to fill up as fast as pitch is dug out of it, and has done so for many years? It is not conceivable that x cubic feet of manjak were squeezed up into a space containing exactly x cubic feet, but it is conceivable that x cubic feet of manjak were squeezed out of x^{1000} cubic feet into a space containing x

* Reproduced from *Text Book of Geology*, by Sir Archibald Geikie, 1885, Fig. 273, page 533.

cubic feet. Therefore, although the writer submits the hypothesis to Prof. H. Louis rather as a theory than as an ascertained fact, the writer looks upon it as the only conceivable theory of the origin of manjak.

As to the danger of fire from the dust, he might say at once that when he first began mining he was very much afraid of accidents from this source, but so far (2 years) there has not been a single fire or explosion. Inbye, where at times the air has been so bad that the lamps will scarcely burn, and the fine invisible dust fills the workings, he has seen a fall of manjak loosen a little heap of dust on the walls, which, falling over a lamp has ignited, and formed a brilliant cascade of fire, but the dust in the air has never ignited. The fact that there has not yet been an accident from this cause, however, does not prove more than that, so far, the requisite proportions of air and dust have not yet occurred, and that in ordinary working, with and without good ventilation they do not occur; but that does not disprove the truth of the President's remark that there is a certain amount of danger in working this material. He might add that some parts of the workings are thoroughly wet—roof, walls, and floor—and other parts as thoroughly dry.

We do not find the trouble to our eyes that Mr. Greener mentions as incident to the filling of pitch at Peases' West Bankfoot. In an article on uintaite (gilsonite) in the *Revue Technique*, it is stated that the Americans find their lungs affected by the dust. We find that the dust penetrates the clothing, and forms a fine varnish on the skin, for although it is insoluble in water the heat of the body seems to be sufficient to soften it enough to make it sticky. For days after an inspection, the writer's beard and hair stained his pillow every night, in spite of thorough washing with kerosene oil, or with turpentine; and that the lungs become covered in the same way is, perhaps, proved by the fact that expectoration for some hours afterwards brings up lumps of black phlegm. He had not found, nor had his workpeople (about 100) complained of, any trouble on that account. They suffer chiefly from chills produced by 5 hours' work in pouring perspiration, and then eating their breakfast in one of the adits, in a thorough draught. Their hours are from 6 a.m. to 5 p.m., with 11 to 12 a.m. off for breakfast. He thought that it was not impossible that the negro can stand more discomfort than the white man.

The width of the veins varies from $\frac{1}{8}$ inch to 30 feet. He imagined that the average width was about 4 feet. At present prices it pays to work a vein 6 inches thick. There are plenty of leaders from the main veins of that width, and these he reserves for working until a fall of wall, or other contingency, will prevent him from working below.

Most of the manjak in this island is found with lumps of dirt interspersed in it. The veins at the Merivale mine are entirely free from any extraneous matter : so much so, that he is able to guarantee it as pure to his customers. There are, of course, horses in the veins ; some so great that we used at first to believe that the vein had pinched out when we came across them ; others smaller, but it is very rarely that we come across a horse of less than 3 cubic feet in measurement. The manjak in the other mines has a quantity of grit in it. In working a vein of 3 feet or less, we cut out the foot-wall for a short distance and then block the manjak down. One of the veins increased from 5 feet to 9 feet in width for a depth of 100 feet and for a length of 150 feet. In such veins, we pick the manjak out and leave the walls. Possibly Mr. Cochrane could give the writer information on a subject connected with this part of our operations. It is not so easy to dispose of the dust on the market as it is to dispose of rubble—at least, not at the same price. Also, it is, of course, highly desirable to make as little dust as possible in the hewing. Using a pick, the stuff breaks away in flaky lumps with sharp edges and conchoidal fracture—it is not laminated like coal—with about 30 per cent. of dust. A heavy pneumatic channeller would not do, because we move forward so quickly that it would cost too much to be continually moving it and the air-pipes. Would it be possible to use one of those small pneumatic riveters, with a cross-cut chisel fixed on it instead of the hammer, and so groove out blocks of about 12 inches cube?

The PRESIDENT delivered the following address :—

PRESIDENTIAL ADDRESS.

By W. ARMSTRONG.

My first duty is to thank you cordially for the great honour which you have conferred upon me in electing me President of this now venerable Institute for the coming year. Conscious of the responsibilities of the position and the important duties which it confers upon its holder, and which are inseparable from it, I can assure you that I fully appreciate the confidence you have reposed in me, and you may be assured that I will endeavour to the utmost of my ability to uphold the prestige of this Institute and further the objects of its foundation as they were enunciated 46 years ago. I ask your assistance and forbearance during my term of office.

After the able and comprehensive addresses of my immediate and remote predecessors on the past history and recent improvements in the coal-trade, so completely narrated and carefully discussed, there seems, at first thought, little left to discourse upon. It has occurred to me, however, that instead of wearying you with debatable and unproved technicalities, I might more profitably occupy your time in reviewing the present position of the coal-trade, particularly with regard to the many difficulties looming in the future, and venture, if possible, to indicate that line of action by which they may be most advantageously met and overcome.

A thorough grasp of any single subject, be it scientific or industrial, cannot be obtained without taking cognizance to a greater or less extent of many collateral subjects. As the title assumed by this Institute embraces mechanical as well as mining engineering, I feel that I am justified in considering any branch under these heads which, in its technique, may be utilized for the efficient and successful working of a colliery.

The success of every industrial concern is to be measured by its dividend-paying results. These are affected :—(1) By trades union organizations shortening the working hours and increasing the price of labour, thereby cutting down profit to a minimum. (2) Foreign competition offering products of an equal or better quality or at a lower price ; and (3) Legislative interference, by insisting on more costly

appliances and processes to secure greater safety where risk to life or limb is concerned, often, though not always, beneficially. These processes must be combatted if our manufacturers are to hold their own in the trade of the world, and upon the success or failure of this hangs the fate of the coal-trade also.

I may safely venture to predict that, far from diminishing, these opposing and disturbing forces are more likely to increase, and the question which I propose to consider is how they are to be met.

Counter-legislation and combination on the part of capital is suggested by many, but political economy teaches us that this policy is short-sighted, and eventually futile, because unscientific.

The struggle is not between capital and labour, where the resources on either side are limited and the results, in whichever way it may end, suicidal; the struggle is between brain-power and the forces of nature, where on each side the resources are unlimited, and the result, as proved by all past processes of evolution, a certain victory. This victory can be obtained only by persistently keeping before us economies in the processes of production.

In passing, permit me to express the opinion that legislation, when exercised beyond its legitimate sphere (the maintenance of order and protection of life and property), far from being a panacea for the ills of life, has generally a retarding effect on progress, and in no instance is this better illustrated than in its application to trade.

Scientific engineering in all its branches has advanced in late years by such leaps and bounds that further improvement, at first sight, seems to be well nigh impossible. Examination of the more modern tools and machines discloses the fact that not only do they turn out work more quickly and cheaply, but the quality of the work is better, and that with a diminished use of skilled labour. The highly paid and skilled workman is gradually being displaced by an almost intelligent machine, the various operations requiring only the attention of boys. In the face of this, it is astonishing to see in the shops of many of our leading engineering firms the antiquated and costly processes still at work. Unquestionably, and especially in this country, many hesitate before consigning to the scrap-heap the machinery, well kept and in good working order, with which their shops are equipped. Nevertheless, with the continued pressure from trades union organization and competition by foreign nations adopting the latest and most improved forms of machinery, our manufacturers will be compelled either to follow suit or, by nature's inexorable law of the survival of the fittest, go to the wall.

The same arguments apply to coal-mining. Higher wages, shorter hours, competition from foreign coal-fields, and legislation increase costs and diminish profits with tenfold force.

Improvements in the direction of winning, laying out, and ventilation, coal-getting, haulage, winding, and preparing the produce for sale have been effected in recent years, though not by any means commensurate with that in the mechanical trades, and for obvious reasons. A workshop may be laid out in any situation and to any design, but the laying out and equipping of a coal-mine depends upon the peculiarities and exigencies of the coal-field. An error in a workshop may be amended, but much of the work done in a coal-mine, whether underground or on the surface, cannot be undone. Hence the greater necessity for care and foresight in all mining operations, and the immense difference between the schemes for laying out a new colliery in virgin coal, proved or unproved, and the reconstruction of one already established and in operation.

Here comes, first of all, the great question of recent improvements in sinking operations, which, being a vast subject in itself, I do not intend further than to mention in passing.

Another important item is the arrangement of the mechanical department, both underground and on the surface, making use of the most recent and best approved appliances, and so arranged that, when future necessity requires it, they may be replaced by improved devices, and so keep pace with the times. This is a matter of almost daily increasing importance.

In old establishments, with wasteful boilers, antiquated and in some cases obsolete machinery, involving a heavy consumption of fuel for purposes of production, which fuel it is the duty of the management to convert into cash, there is much scope for improvement, without which the ultimate object, profit, must materially suffer.

Each decade brings with it modifications and improvements on old methods with increasing rapidity, which in the business of to-day, so different from that of a generation ago, cannot be ignored. I will now briefly summarize some of these :—

Prime Movers.—These afford in themselves an abundant field for consideration and discussion as to structure, steam-raising and distribution.

Boilers.—These and the methods of firing them have been the subject of much controversy, attended by many important improvements ; but there is yet room for more. High pressures, varying from

100 to 160 lbs. per square inch, and even higher, are being adopted, and in boilers of the Lancashire type with most satisfactory results, the obsolete and condemned egg-ended type being, and very properly so, thrust aside. Where high pressures are adopted, abundant capacity both for water and steam space are important factors in economical working. Twenty years ago the bare mention of the probability of boilers one day being worked on such a load, and especially at collieries, was flouted and ridiculed. Improvements in construction brought about by improved tools and the adoption of steel instead of iron have made this possible.

The questions of economical firing and dealing with impure feed-water, especially when charged with lime, salts, etc., afford a considerable field for useful thought.

Although the bogey of a declining coal-supply does not, thanks to modern discoveries, disconcert our economists as formerly, the increased cost of coal-production and consequent increase in value, however convenient, places us in the same dilemma. When this is fully appreciated, as great care will have to be observed with colliery-boilers as obtains in factories where fuel has to be purchased. Where there is an abundance of waste-heat from coke-ovens which may be utilized, the importance of these matters is considerably minimized.

Engines.—Much has been achieved of late in improvements of engines, especially those used for winding. The application of high-pressure steam with automatic cut-off valves has brought this class of machinery to as near perfection as possible. I cannot think that compounding these will be successfully and safely worked, as it must involve complications, which should be avoided above all things; nor do the continual interruptions in running point to the economy claimed for it.

I am strongly in favour of condensers being applied wherever possible; those of the evaporative type, into which all or most of the engines on a colliery may exhaust, are well worthy of careful study; and it is unnecessary for me to enlarge upon the economy gained by such an appliance, even though the first cost be high.

In all new mines, and I may also include those in present working, mechanical coal-getting should be looked forward to as an indispensable requisite. This points to the adoption of the longwall method of working whenever practicable, as it is the only system to which it can be successfully applied.

A matter of no little importance is that of improving the saleable value of inferior coal by washing. It has yet to be determined which is the most efficient and economical apparatus, and information is still required in this direction.

Electricity.—Electricity as a force has been so extensively used in recent years that it has exceeded the expectation of its most sanguine advocates. Mr. Hippolyte Fontaine, in a paper read by him before the Institution of Mechanical Engineers in June, 1878, states in his opening paragraph that:—"The number of industrial applications, which was 4 in 1874, and 12 in 1875, was raised to 85 in 1876 and to 350 in 1877; whilst at present there are upwards of 500 applications of the light, amounting in intensity to more than 1,500,000 candles."*

It is now 20 years since this was written, and we have only to look at the immense strides which the adoption of electricity has made everywhere. This is chiefly due to the invention of the incandescent system of lighting as compared with the arc system, which was the only one in vogue in 1878. And our author goes on to state that:—"The electric light does not interfere with gas light, nor with oil light, nor with candle light. It will not revolutionize, as has often been averred, the question of lighting, destroying what is now in use and monopolizing every industrial application, domestic and public. The electric light has its place marked out for it under many circumstances; but, far from diminishing the consumption of other lights, it will lead to their further development by demonstrating the advantages of a more powerful and more complete illumination."†

These prophetic utterances have been borne out, and upon a scale which was in all likelihood beyond the writer's most sanguine hopes, and I venture to think in almost every detail. We have only to look at the enormous extension in the gas-factories of our large towns to have this fact conclusively demonstrated.

I am strongly of opinion that the same utterances will apply to its use for motive purposes. As such it is becoming better understood, and its distribution from central-power stations in some of the more important factories at home and abroad, in every instance with a marked saving in labour and fuel, points to its more extended adoption. The chief factor against it has been the high initial cost of its installation, and in some cases of its upkeep. This was owing sometimes to errors in estimating the work which it was to perform, sometimes to false economy in cutting down first cost. These mistakes are fatal to success in any exploitation. I think that I am correct in saying that most electricians are agreed that a margin of 50 per cent. above the work required from a generator is necessary for economical working. The great convenience of its application is a considerable factor in the argument for its almost universal adoption at collieries and other industrial concerns in the near future.

* *Proceedings*, 1878, page 529. † *Ibid.*, page 529.

In considering the future of any industrial concern, it is not sufficient to assume that because everything is laid out, constructed and worked on the latest principles, it will be a permanent success. It must be borne in mind that in machinery there is constantly at work an evolutionary process abreast of which every business must keep or fail. The usual depreciation fund for wear-and-tear of machinery is not sufficient, the producer must not content himself with the renewal of a machine when it is worn out, but must immediately supplant it by a better. This implies that in future industrial economics will require the matter of a depreciation fund, securely invested, to be considered on a much broader basis than that to which we have been accustomed. If Great Britain is to keep her place as mistress of the world, this all-important factor must be reckoned with.

To students I would say, cultivate careful and accurate observation, associate with this intelligent reasoning on scientific principles, and upon this base the practice by which means only can the desired end to which your labours are directed be attained. Be not dismayed by difficulties, rather court them. The experience gained in battling with them will be of undoubted advantage to you.

To the working-man seeking shorter hours, higher wages, and less laborious occupation, I would say, bear in mind that these cannot be got by fruitless agitation against the capitalist, beholding him as an enemy, but by joining him as an ally and friend and wielding against the forces of nature his only successful weapon, education. When the scales have fallen from the working man's eyes and he recognizes his vantage ground, trade disputes with their concomitant miseries will have become ancient history.

If by these somewhat discursive and speculative remarks I should succeed in supplying to those engaged in colliery practice subject-matter for serious thought, I shall feel satisfied that these my feeble efforts have not been in vain.

Mr. G. B. Forster said that, after hearing the President's very able review of the conditions and prospects of their staple industries, the members would agree that between the law, the foreigner, and the workman, it behoved them to set their houses in order, and make the best they could of existing circumstances. He was present at the first

meeting of members of this Institute, which had for its object the effecting of improvements, first of all, in matters of safety, and, secondly, in matters of working, and he thought, on the whole, that the Institute had fully discharged its duty. Addresses, such as that given by the President, were of great advantage to the members, as they pointed out fields in which their explorations should go and points to which their attention should be directed. He had great pleasure in proposing a hearty vote of thanks to Mr. Armstrong for his address.

Mr. William Cochrane, in seconding the vote of thanks, said that Mr. Armstrong had so experienced a knowledge of what had been done in the past that he was sure the members would reap great advantage therefrom during his tenure of office.

The President briefly acknowledged the vote of thanks.

The following paper by Mr. S. J. Becher on "The Nullagine District, Pilbarra Gold-field, Western Australia," was taken as read:—

THE NULLAGINE DISTRICT, PILBARRA GOLD-FIELD, WESTERN AUSTRALIA.

By S. J. BECHER.

The Pilbarra gold-field, although perhaps the least known of the Western Australian gold-fields is, with the exception of the Kimberley and Yilgarn fields, the oldest in the colony, having been proclaimed in 1889, while the others were respectively proclaimed in 1886 and 1888, gold having been found in all at much earlier dates. It occupies a total

Fig. 4.—Hill of Actinolite-rock.

area of 45,600 square miles, being now subdivided into the Pilbarra gold-field (35,100 square miles) and the West Pilbarra gold-field (10,500 square miles), the two abutting on the north-western coast for a distance of about 200 miles.

Nullagine, as will be seen on the accompanying map (Fig. 1, Plate III.), is situated on the Pilbarra gold-field about 180 miles by road south-south-east from Condon, and 300 miles by road east-south-east

from Roebourne; Marble Bar, the head-quarters of the Warden of the Pilbarra gold-field, being situated on the Condon road about 100 miles from the coast. Taking this road as a base-line inland, the main geological features observable, until Marble Bar is reached, are restricted in variety to the occurrence of belts of diorites, schists and limestone, forming broken hill-ranges, often crested by a backbone of jasperoid quartzite, which traverse the otherwise prevailing granite-plains in a northerly direction, varying slightly a few points east or west of north, and dipping universally westwards.

After passing Marble Bar, leaving the Coongan river on the west, the road winds for some 10 miles through broken ranges of diorite and schistose rocks, whose sides are scarred with innumerable quartz-reefs,

FIG. 5.—PORTION OF HILL, SHOWN IN FIG. 4.

the most noticeable feature being a range of actinolite-rock, views (Figs. 4 and 5) of a portion of which are appended hereto. In the vicinity of this range, the surrounding schists assume a similar structure, and even so the quartz (superficially) of the reefs. For some miles again, after leaving this belt of country, the traveller journeys over a vast granite-plain. Beyond this plain, one sees the last of the granite, and the road immediately commences to rise into the heart of an apparently extremely

rough country, which, however, is really less forbidding than one anticipates. The former characteristic features of the landscape give place to higher ranges of broken hills, which preserve no very systematic trend. They consist of trappean and basaltic rocks, and huge weathered boulders hang on their rough flanks in a threatening manner, while the gorges and creek-beds are strewn therewith.

Occasionally the country opens out, and the road passes over lower and flatter ground, traversed by creeks and sparsely timbered. As one approaches Nullagine, the features again alter, and the sections exhibited in the gorges and on the hill-sides show well-defined formations of grits, slates, sandstones and conglomerates, having a general strike to the north-east, and dipping at low angles to the north-west. The rugged broken crests of the ranges give place to long round-backed heights and table-topped hills ; these latter are mostly isolated hills capped with thick masses of ironstone, cement and conglomerate, covering a substratum of kaolin. These hills are characteristic of this district of the Pilbarra gold-field, and they will be referred to hereafter.

In the immediate vicinity of Nullagine township or mining camp, range upon range of conglomerate-hills lie to the north-west, while on the eastward as one approaches the township (and the characteristic galvanized-iron buildings, tents and bush-huts come into sight), there is a reach of undulating country, dotted with isolated flat-topped hillocks and low ranges, extending some miles beyond the bed of the Nullagine river, whose course is marked by a wide belt of timber and scrub.

The river runs only after a flood, but the pools left therefrom and shallow wells have provided an abundant water-supply for the small population. The quality of the water is very good.

Far away across the low-lying country, with its low, broken ranges, may be seen the Ripon Hills, which form the water-parting between the Oakover and Nullagine rivers.

The course of the river, as indicated on the accompanying locality sketch-map (Fig. 2, Plate III.), follows the outskirts of the conglomerate country, keeping on the further side of the slate country and its quartz-reefs, and forms a marked line of division, as it were, between the characteristic topographical features of the district.

In the township, about ¼ mile from the western bank, a well-shaft was sunk through 33 feet of clay-slate, below which sandstone was met with carrying a good supply of water. There are several other good wells. At the side of the road, going thence towards Beton's Hill, the clay-slates are seen in a section on a creek-bank to be folded sharply in

anticlines of only a few feet in height. This is the only spot in this neighbourhood where the writer noticed anything of the kind, the country generally appearing to be much less disturbed than that lying north and west towards the coast.

Beton's Hill forms one of a group of the abovementioned flat-topped hills or hillocks situated in a bend of the conglomerate country, the river forming hereabouts a chord of the arc. Another hillock of note is Cook's Hill, named after Nat Cook, the explorer and prospector who was the first to find gold in the district some 12 years ago. The former hill is named after Beton, who at a later date, when the Nullagine "rush" was at its height, traced alluvial gold from the adjoining flat into the kaolin at the base of the hill, and followed the run by tunnelling and took out a very considerable quantity of gold.

This kaolin, varying in thickness from 10 to 50 feet, has been highly coloured in places by the action of percolating mineralized waters, and probably too during the original process of decomposition. Capping the kaolin, in a flat bed varying in thickness from 1 to 10 feet, is a mass of highly ferruginous matter, mostly very hard. Much of it is either a compact body of ironstone-conglomerate, or nearly pure hæmatite; some however is vesicular and offers less resistance to denudation. The writer may add that the same ironstone-formation may be seen in many places throughout the whole length of the colony, sometimes merely capping hills or ranges, and sometimes forming the surface of a table-land extending for many miles.

On the flats, between these isolated hills and below the main conglomerate-ranges, an immense amount of work has been done by alluvial diggers. The ground, where the alluvium attains any depth, is all turned over and over and heaped up afresh, while up the gullies regular walls of the larger stones, originally lying in the creek-bed, may be seen heaped up on either side of the watercourse. Then again the gold has been traced up the hills, and the curious sight may be seen of whole hill-sides, and even the very tops too, dotted with little heaps of stones and the rest of the ground swept bare to the hard surface. The alluvial material has been treated for gold by roughly screening, and then puddling and sluicing in hollowed-out tree trunks at a pool in the river, or merely by dry blowing.

Here and there, on these flats, outcrops of clay-slate and sandstone occur.

Coming then to the conglomerate-ranges, which average in height about 100 to 150 feet above the level of the river-flat, we find that the

upon examination. Following up into these ranges an affluent of what is known as the Main creek, one enters a gorge with precipitous sides rising to 50 feet in height, and here a very fine cross-section of the country may be examined. Here it may be seen that, interbedded conformably with the beds of conglomerate, there are indurated slates and grits. The former, where long exposed to the action of the atmosphere and water, split off into flags.

Compared with the abovementioned series, little or no decomposition has taken place beyond surface-weathering, which accounts probably for the fact that no free gold (to speak of) has been obtained in the gullies, and that the terraced series is not at present recognized as auriferous. Time may prove this. The terracing is due to the unequal effect of weathering on the exposed longitudinal edges of these otherwise undecomposed beds of varying durability.

As to the age and origin of these interesting Nullagine beds, nothing definite is yet known. Beyond a cursory examination some years ago by the late Government Geologist of Western Australia, Mr. H. P. Woodward, at which time, the writer believes, no work had been done upon them, no geologist has thoroughly studied them. In some samples brought down by the writer, the mineralogist of the present Geological Survey Office recognized the occurrence of volcanic bombs.

A curious fact in connexion with the composition of these conglomerate-beds is that when cleaning up after battery-crushings, small diamonds have on several occasions been washed from the residual sand and stone taken from the battery-boxes; and, in many instances, diamonds have also been obtained by men when washing the alluvial from the gullies and flats for gold. Few stones, however, of sufficient size to be of commercial value have been obtained. Tradition states that the local test for their authenticity has been to put the stone on an anvil and strike it a blow with a sledge-hammer!

The writer has before mentioned that the course of the Nullagine river marks roughly the outline of the above-described country in this neighbourhood, and that on the eastern side of the river very diverse conditions are noticeable. The country is generally almost flat, but is crossed by fairly parallel belts of low outcrops forming ranges of slate-hills, while about 1 mile from the Nullagine township two low, much weathered, and broken ridges of igneous rock protrude above the surface for a distance of 2 miles.

The flats themselves consist of the same slates as the ranges, though naturally in a soft decomposed state, being liable to submergence at flood-

To illustrate Mr. S. J. Becher's Paper on "The Nullagine District, Pilbarra Gold-field, W.A."

Fig. 1.—Sketch Map of the Pilbarra and West Pilbarra Gold-fields, W.A.

Fig. 2.—Sketch Locality Map.

Not Drawn to Scale.

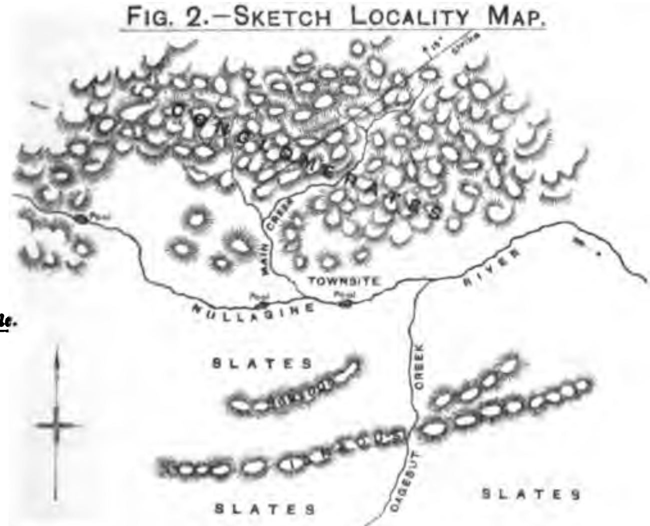
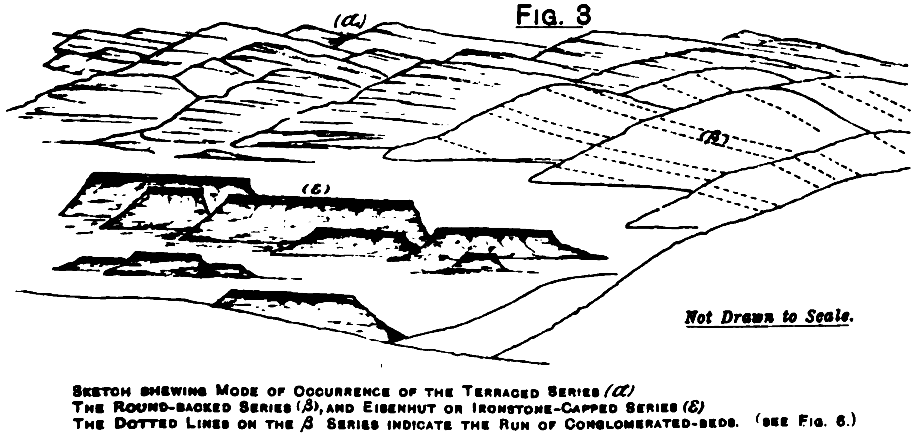


Fig. 3



Not Drawn to Scale.

Sketch shewing Mode of Occurrence of the Terraced Series (α)
The Round-backed Series (β), and Eisenhut or Ironstone-capped Series (ε)
The Dotted Lines on the β Series indicate the Run of Conglomerated-beds. (see Fig. 6.)

time, and carrying the drainage-waters from the hills. These slates apparently also dip to the north-west and lie somewhat flatly. They are traversed by a network of quartz-reefs and leaders. The main reefs, however, run with the country, striking north-east. The surface is strewn with their *débris* and dry-blowers have gathered good harvests therefrom. About 3 years ago, attention was attracted to the reefs themselves by the discovery of several very rich patches of stone on their outcrops, and since then a considerable amount of mining has been done and many good crushings have been taken out.

The character of the quartz in the big reefs is mostly very white and vitreous, and in this kind of stone the gold is generally coarse and occurs in bunches. While in smaller reefs, and sometimes in certain splices of the big ones, a more kindly-natured stone is found, showing perhaps fine gold and prospecting well all through. Smaller reefs vary not only in strike, but in dip very much. Some lie somewhat flatly with the country-rock, while others are practically vertical. Some dip eastward, and some westward.

The writer was shown some much-decomposed calcite, carrying wonderfully rich gold in a very fine powdery form, taken from a small vein, but could gain no information about the locality of the find as the prospector had left the district.

No fossils have yet been found in this district.

Mr. H. M. Cadell (Bo'ness, N.B.) said that he had visited the Pilbarra gold-field in 1895, and had heard of the Nullagine district and seen specimens of the diamonds from the conglomerate in that part of Western Australia. The value of the gold-field had of recent years been greatly exaggerated by interested people desirous of making money by selling mining properties to British investors. There were no doubt gold, antimony, copper, tin, lead, manganese, and magnetic and hæmatite iron-ore deposits of some value in various parts of the district which at other places might be workable at a profit. But he did not think that any mining company would continue operations very long in that inhospitable and remote tropical region. The author of the paper wisely said little about the prospects of successful mining. The climate was such that no white man could be expected to survive many years of exposure to it, and the mining laws of Western Australia prohibited the employment of Asiatic or coloured labour, capable of enduring the

heat. In summer, the temperature in the shade often reached 120° Fahr. For many months there was little or no rainfall, and the region was a terrible dry wilderness parched with scorching heat. The drought was varied at times by terrific storms of wind and rain locally known as "Willie Willies." One of these occurred some months ago and blew down nearly every house over a wide region, while rain fell in torrents and devastated the country far and near. At one mine, the only place of shelter was found under the boilers, and the manager was driven even out of that wretched retreat by the water rising to the level of the furnace-bars. It was unpleasant to speak the truth at times, but he (Mr. Cadell) considered it his duty to warn mining engineers at home against that part of Western Australia. Gold was no doubt to be found on the surface in quantities sufficient to dazzle the eyes of inexperienced people. The natural drawbacks, however, were so great in the way of cost of living, excessive difficulty and cost of transport, absence of fuel, and severity of climate, that nothing but the very richest of mines could be worked at a profit. For thousands of miles there were no safe and adequate natural harbours on the coast where heavy machinery could be safely landed, and this geographical drawback would never be satisfactorily overcome. He had followed the history of the Pilbarra gold-field with some interest, and it was a history of successive defeat and disappointment. Geologically the district was interesting, as there was a great variety of rocks and minerals, and Mr. Becher had done well in adding to the very meagre information that had been published on the rocks of the Pilbarra gold-field.

DISCUSSION OF MR. FRANK REED'S PAPER ON "HYDRO-THERMAL DEPOSITS AT PEAK HILL, WESTERN AUSTRALIA."*

Mr. Frank Reed, replying to Prof. H. Louis' remarks, wrote that the title of his paper conveyed the meaning he intended ; and by thermal crater, he meant the orifice of a fissure, originally caused by volcanic activity and afterwards used as an outlet for thermal waters

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* *Trans. Inst. M.E.*, vol. xiv., pages 89 and 538.

THE MINING INSTITUTE OF SCOTLAND.

ANNUAL EXCURSION.

AUGUST 25TH, 1898.

Fully 100 members, conveyed by train from different parts of the country, met at Stirling and were driven in brakes to the Alloa Coal Company's Bannockburn Colliery.

BANNOCKBURN COLLIERY.

Bannockburn colliery is situated about 4 miles from Stirling, and is connected with the Caledonian Railway at Plean Junction by means of a siding ½ mile in length. The area leased extends to nearly 4,000 acres. Two shafts, 18 feet by 10 feet and 14 feet by 6 feet respectively, have been sunk, passing through the following seams :—

Name of Coal-seam.	Thickness. Feet.	Inches	Depth from Surface. Feet.
Bannockburn Hartley	2	4	... 786
Steam	3	0	... 997
Bannockburn Wallsend	3	0	... 1,002

The first and third seams are now being worked.

The following are analyses of the Bannockburn Wallsend coal and of foundry coke made from the same coal :—

	Coal. Per Cent.	Foundry Coke. Per Cent.
Volatile matter	29·10	...
Carbon	66·50	96·68
Ash	2·10	2·90
Sulphur	0·05	0·36
Water	2·25	0·06

Water is raised by means of a compound condensing pumping-engine, having cylinders 20 inches and 34 inches in diameter respectively and 5 feet stroke, the initial steam-pressure being 100 lbs. per square inch. The water is pumped in three lifts : the top lift delivering by means of two rams 22 inches in diameter. The method of working is longwall.

A Guibal fan, 30 feet in diameter and 8 feet wide, driven by a compound engine, with cylinders 12 inches and 22 inches in diameter respectively, produces 130,000 cubic feet of air per minute, under a watergauge of 1·50 inches at 50 revolutions per minute.

The necessary steam is raised in Lancashire boilers heated by the waste-gases from the coke-ovens. The three chimneys are 130 feet high and 6 feet square inside.

The winding-engines at both pits are similar, being horizontal with coupled cylinders 20 inches in diameter and 5 feet stroke, fitted with cylindrical drums 15 feet in diameter. Each cage holds 2 hutches containing 11 cwts. each of coal.

The surface-works are lighted by electric lamps. The coal from each of the two seams worked is treated separately in a Lührig washing and picking plant, the small coal being used for coke-making.

After the hutches are landed at the top of each pit, they are run by gravity to the tipplers. The empty hutches are raised thence by an endless-creeper and run by a circular route to the top of each pit by gravity. A mechanical arrangement enables the empty hutches to change the switches themselves, and the tubs pass automatically into the rise- and dip-cage alternately.

Beehive coke-ovens are built in a double range to the number of 104, each being 11 feet in diameter and 7 feet high. There is a main flue in the middle of the range which conveys the waste-gases from the ovens to a brick-chamber in front of the steam-boilers. From this chamber, branch pipes of wrought iron convey the heated gases to each of the boiler-flues. The washed small coal is run from the hoppers of the washing-plant into waggons of wrought iron each holding 1 ton. These are raised by means of an endless-chain to the level of the top of the ovens, whence they run by gravity, discharging the coal into the top of the several ovens as required.

There are 140 workmen's houses.

The existing plant has been designed to produce ultimately from 1,500 to 2,000 tons a day.

A General Meeting of the members was held at Stirling.

The following gentlemen were elected :—

MEMBERS—

Mr. RENWICK COWAN, Linlithgow Oil Company, Linlithgow.
Mr. GEORGE GIBB, Candie House, Avonbridge.
Mr. FRANCIS WEBSTER, 2, Athole Gardens Terrace, Glasgow.

ASSOCIATE MEMBER—

Mr. SAMUEL M. THOMSON, 208, West George Street, Glasgow.

STUDENTS—

Mr. ROBERT FORRESTER, Green Street, Bothwell.
Mr. JAMES H. MACARTHUR, Etteridge, Newtonmore.
Mr. ALEXANDER MACKAY, Askam-in-Furness, Lancashire.
Mr. DAVID T. H. MCQUEEN, Redlands, Wishaw.
Mr. EDWIN J. VALLENTINE, Bank House, Brechin.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,
OCTOBER 12TH, 1898.

MR. JAMES T. FORGIE, PRESIDENT, IN THE CHAIR.

GLASGOW SUBWAY.

Through the kindness of the Glasgow District Subway Company, the members visited their power-station. The members were met by Mr. William Dick Maclean, the superintending engineer, who with two of his assistants took them in charge, and described the interesting features of the engines, cables and connexions, and steam and electric plant.*

On the motion of the PRESIDENT, a vote of thanks was given to the directors and engineers of the subway and to Mr. Maclean.

The minutes of the last two General Meetings were read and confirmed.

The following gentlemen were elected :—

MEMBERS—

Mr. JOHN EVERARD ANDERSON, 41, Westbourne Gardens, Glasgow.
Mr. JOHN MCGREGOR, Whifflet, Coatbridge.

DISCUSSION ON MR. WILLIAM S. THOMSON'S "NOTES ON A HEATER RECENTLY ERECTED AT CADZOW COLLIERY."†

Mr. W. S. THOMSON wrote, with reference to the feed-water being raised only to the temperature of 175° Fahr., that he might draw attention to a point which had evidently been overlooked, namely, that at the time when the temperature of the feed-water was taken (and showing it to be 175°) the condenser had not been completed, and

* A description of the engineering features of the subway and of the power-station is contained in *Engineering*, vol. lxii., page 574; and a short illustrated description in *Cassier's Magazine*, vol. xiv., page 459.

† *Trans. Inst. M.E.*, vol. xv., pages 130 and 258.

therefore had not been connected up to the heater. Since these connexions had been made, the temperature of the feed-water had been found to vary from 202° to 204° Fahr., and compared favourably with similar arrangements mentioned in the discussion.

Mr. JAMES MCVIE (Cadzow colliery) said that about 4 years ago an endeavour was made to improve the heating of the feed-water at Cadzow colliery. There were then 14 Lancashire double-flued boilers, 5 being at No. 1 pit and 9 at No. 2 pit. A locomotive boiler with 120 brass tubes was used for heating the feed-water at No. 2 pit, and had been in use for 2 years. An economizer with 384 tubes, 4½ inches in diameter and 9 feet long, was placed on the flues of 7 of the boilers. The cold water was pumped from the pond through the locomotive-boiler, and the steam from the cylinder, 36 inches in diameter, of the fan-engine, was exhausted through the fire-box and tubes of the boiler so as to heat the water, which then passed through the economizer and entered the boilers with a temperature varying from 140° to 160° Fahr. However, the required quantity of steam could not be produced, although 4 men were employed in firing and taking out ashes, and 2 waggons of Ell coal dross were daily mixed with the other dross-coal. On examining the locomotive-boiler, it was found to be filled up with dirt between the tubes.

A tube was then made, 90 feet long and 5 feet in diameter, fitted with an internal tube, 18 inches in diameter, running from end to end; the exhaust steam-pipes from the fan engine were attached to one end, so that the exhaust-steam might be passed through the internal tube; together with the exhaust-steam from the winding-engine, with two cylinders, each 24 inches in diameter, the haulage-engine with two cylinders, 16 inches in diameter, and the donkey-engine. This water-heater was covered with brickwork, the side-walls being 18 inches thick, with an arch, 9 inches thick, on the top, and the ends were also built up. The brickwork was kept 18 inches clear all round the 5 feet tube, so that the exhaust-steam could pass along the sides and discharge at the bottom of the opposite end. After the feed-pipes were attached to this heater, the water had a temperature of 190° Fahr.

On examining the economizer. it was found that about 250 of the tubes were closed, and a rod of iron (¼ inch in diameter) could not be passed through them; but when cleaned and in working order the water was heated to 230° Fahr., and two men are sufficient for the firing of these boilers.

At No. 1 pit, there was a cast-iron tube, 28 feet long and 30 inches in diameter, in which a 4 inches tube was passed along and back again; the large tube formed part of the exhaust steam-pipe from the winding-engine to the chimney. After being 2½ years in use, it did not heat the water in the least, and it was with difficulty that as much water could be passed through as would keep the boilers working, and, in addition, there was a back pressure on the winding-engine which could not be allowed to continue.

The water-heater described in the paper was adopted, so as to allow dirt to settle and be easily removed. The water used at Cadzow colliery is bad, and the deposit has in 2 years completely closed a pipe, 4 inches in diameter, at a temperature of 150° Fahr.

The President remarked that one of the advantages of heating feed-water was that it took the scale out of the water. The bulk of the water used in feeding boilers at collieries was taken from the pit, it was often very hard, and contained a large percentage of lime, the tendency of which was to leave a great deal of sediment and cause an incrustation or deposit on the bottom and sides of the boiler; but by the heating system, while the pipes and heater became choked, the deposit was more easily dealt with there than in the boiler. At the Glasgow District Subway power plant, a Berryman heater, using Glasgow water-supply, kept the temperature of the feed-water up to 202° and 204° Fahr., and with feed-water at 190° he did not think that much was lost.

Mr. McVie said, in reference to a heater employed for heating cold water for the workpeople, that the water was supplied by the county council to the heater, which rose to 190° Fahr. The tubes had recently been taken out of the heater, and there was nothing wrong with them.

Mr. Clark (Eskbank) said that he had had a heater fitted with tubes 2½ inches in diameter. The boilers were supplied with water got from the Tranent Water Commissioners, there was a little lime in the water, and the tubes closed up in about 6 months with a temperature of about 190° Fahr.

The President closed the discussion, and on his motion a vote of thanks was given to the author of the paper.

DISCUSSION OF MR. ROBERT MARTIN'S PAPER ON "UNDERGROUND STEAM-APPLIANCES AND TEMPERATURE OF THE STRATA AT NIDDRIE COLLIERIES."*

Mr. R. MARTIN, replying to Mr. Gemmell's question, wrote that the rate of condensation, per square foot of surface exposed, appeared to be about 0·73 pound of steam per hour. This loss or condensation is that due to the use of uncovered pipes, but the total or dead loss in this case is due, not only to condensation, but largely to steam blown off at the relief-valves on the cylinders and pipes, so as to maintain the long range of pipes free of water. Owing to excessive priming from the boilers, none of the steam-traps that have been tried as yet have given satisfaction by draining off the condensed water.

The PRESIDENT regretted that he had been unable to find the piece of wood, which, as he explained at the last meeting, had been charred by steam.

Mr. MCVIE mentioned that timber uprights had been taken out at Cadzow colliery, and they were burned 1½ inches down.

The PRESIDENT, in closing the discussion, said that the paper contained a description of an underground steam arrangement which was erected some time before the more modern methods of conveying power were introduced. He did not suppose that, with electricity and compressed air at their disposal, they would nowadays set up so great a length of steam piping. The paper showed how steam could be conducted for a long distance underground with fair economy. He concluded by moving a vote of thanks to Mr. Martin for his paper, which was heartily accorded.

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* *Trans. Inst. M.E.*, vol. xv., page 262.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD AT THE HARVEY INSTITUTE, BARNSLEY, AUGUST 3RD, 1898.

MR. G. BLAKE WALKER, RETIRING PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated:—

MEMBER—

Mr. JOHN WILSON, Mechanical Engineer, 35, Acton Street, Laisterdyke, Bradford.

ASSOCIATE MEMBER—

Mr. HARRY KENT, Coal-owner, 4, St. Dunstan's Alley, St. Dunstan's Hill, London, E.C.

The Annual Report of the Council and the statement of accounts for the past year were read as follows:—

THE COUNCIL'S ANNUAL REPORT.

The Council have pleasure in presenting to the members of the Institute their report on the work of the past year.

The number of members for the past two years is as follows:—

	1896-97.	1897-98.
Life Members	4	4
Honorary Members... ...	11	11
Members	221	228
Associate Members ...	9	9
Associates	19	17
Students	16	12
	280	281

If all the members had duly paid their subscriptions, there would have been an increase in all classes during the year of 24.

Of the £22 10s. of arrears of subscriptions for 1896-97, £13 10s. have been collected during the past year; arrears amounting to £9 10s., extending over a longer period, have also been recovered, bringing the total amount of arrears collected up to £23. There is, however, a balance of £9, which has now been written off as irrecoverable.

The Council regret to state that there has been during the past year considerable irregularity in the payment of subscriptions, the arrears amounting to £36 from 24 members, as against £22 10s. in the previous year, notwithstanding that repeated applications have been made by the treasurer for payment. This deficiency does not yet appear in the balance-sheet, as the Council hope that this matter having been prominently brought before the attention of the members, the arrears will be at once liquidated, so as to make it unnecessary to cancel the membership of those in arrear. The Council would draw attention to the fact that the increased calls made by The Institution of Mining Engineers for publication and other expenses leave the Institute scarcely any margin, and that unless subscriptions are regularly paid, they have no alternative but to cancel the membership of those members who are in arrear or to increase the subscriptions all round.

It would save much trouble both to the treasurer and the members themselves if more members would avail themselves of the system of giving orders to their bankers for the regular payment of their subscriptions, as no doubt many of these arrears arise from oversight. Forms for this purpose will be sent to all members by the secretary, and those members who have not already given them will, it is hoped, now do so.

The Council regret that no arrangements have as yet been made to allow of the participation of practical mining engineers in the testing of explosives permitted to be used in fiery mines, and they desire to endorse once more the conclusions arrived at in the special report of their Committee on this matter.*

Much useful work has been done by the Institute during the year, although the number of papers read is fewer than the Council had hoped for.

Two very successful meetings have been held in conjunction with the Chesterfield and Midland Counties Institution of Engineers, and it is believed that the Councils of both Institutes recognize the very great

* *Trans. Inst. M.E.*, vol. xiv., page 415.

advantage which results from these opportunities afforded to the mining engineers of the two contiguous districts to meet and discuss matters of professional interest, meetings which also assist in promoting identity of aim and action between the two Institutes.

The number of papers which have been published by The Institution of Mining Engineers, and of which members of this Institute have had the benefit, have been fully as numerous and important as in previous years.

The title of The Federated Institution of Mining Engineers has now been changed into that of "The Institution of Mining Engineers," and the Institution may be henceforth considered to rank with those representative of other branches of the engineering profession.

Mr. H. B. NASH, in presenting the accounts, said that the only difficulty they had as an Institute was that as The Institution of Mining Engineers grew, the number of papers increased and became more expensive, and the call due from this Institute became more onerous. It appeared that the cost of working their Institute and their proportion of the calls paid to The Institution of Mining Engineers came to 29s 3d. per member, so that they could not expect to increase the balance in hand with 9d. per member.

The CHAIRMAN moved the adoption of the report and statement of accounts.

Mr. JOHN NEVIN seconded the motion, which was carried.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1898-99.

The scrutineers reported the result of the election as follows :—

Mr. W. H. CHAMBERS.
Mr. H. ST. JOHN DURNFORD.
Mr. W. E. GARFORTH.
Mr. J. LONGBOTHAM.
Mr. H. B. NASH.
Mr. JNO. NEVIN.
Mr. E. W. THIRKELL.
Mr. G. BLAKE WALKER.
Mr. F. N. WARDELL.

DR. THE TREASURER (Mr. T. W. H. MITCHELL) IN ACCOUNT

MECHANICAL

	£ s. d.	£ s. d.
July 1st, 1897.		
To Balance at Bankers	40 15 8	
„ Cash in Treasurer's hands	4 4 0	
		44 19 8
June 30th, 1898.		
To Subscriptions for 1897-98	385 10 0	
„ „ paid in advance for 1898-99	4 10 0	
„ Arrears	23 0 0	
		413 0 0
„ Sale of Dinner Tickets	10 14 6	
„ Members' portion of the Wine Account at the Annual Dinner	1 15 0	
		12 9 6
„ Sales of *Transactions* and Authors' Copies of Papers ...		4 2 0
„ Letting of Room		1 7 6
„ The Institution of Mining Engineers—Instruments for Fan Experiments, one-third portion		34 6 8
„ Bank Interest		4 11 4
		£514 16 8

Examined and found correct,

H. B. NASH,

C. E. LONGBOTHAM,

July 25th, 1898. AUDITORS.

WITH THE MIDLAND INSTITUTE OF MINING, CIVIL AND ENGINEERS, 1897-98. CR.

	£ s. d.	£ s. d.
June 30th, 1898.		
By The Institution of Mining Engineers:—		
Call of 19s. per Member on 266 Members for 1897-98	252 14 0	
„ Balance of Call for 1896-97	7 13 0	
„ Excerpt *Transactions*, etc.	17 6 4	
„ Proportion of cost of Exchanging *Transactions* with other Societies	2 0 0	
		279 13 4
„ Annual Dinner		15 7 0
„ Printing and Stationery		15 13 10
„ Office Rent		12 0 0
„ Reporter		8 15 0
„ Insurance		1 11 6
„ Cleaning		0 6 0
„ Gas Company		0 5 2
„ Hire of Rooms for Meetings at Manchester, Sheffield, and Leeds...		5 2 0
„ Secretary's Salary	£50 0 0	
„ „ Expenses	16 0 0	
		66 0 0
„ North of England Institute of Mining and Mechanical Engineers (Mr. Pringle's Subscription)		3 10 0
„ Stamps, Telegrams, Carriage, Wrappers, and Sundries		14 11 1
„ Balance at Bankers	£86 17 0	
„ Cash in Treasurer's hands	5 1 9	
		91 18 9
		£514 16 8

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL STATEMENT, 1897–98.

LIABILITIES.

1898.	£	s.	d.
June 30.—To Sundry Creditors	16	9	5
„ Balance, being capital	431	6	4
	£447	15	9

ASSETS.

1898.	£	s.	d.	£	s.	d.
June 30.—By Cash in Bank	86	17	0			
„ „ „ Treasurer's hands ...	5	1	9			
				91	18	9
„ „ Value of 6,835 parts of *Transactions*, at 1s. ...	341	15	0			
„ „ Value of 116 Copies of Narratives of Sudden Outbursts of Gas, at 1s.	5	16	0			
„ „ Value of 118 Copies of Committee's Report on Safety-lamps, at 1s.	5	18	0			
„ Value of 16 Copies of Report of French Commission on Use of Explosives, at 3s. ...	2	8	0			
				355	17	0
				£447	15	9

Examined and found correct,

H. B. NASH,
C. E. LONGBOTHAM, } Auditors.

July 25th, 1898.

ALTERATION OF RULES.

The CHAIRMAN said that the first alteration, which stood in his name, related to Rule 6, but with the permission of the meeting he should not move that first alteration of rule. With regard to Rule 11, he moved that in lines 3 and 4, the following words be omitted: "shall be held in the rooms of the Institute at Barnsley." He moved this in order to give the Council freedom to arrange for the meeting to be held in some other town in the district covered by the Institute, if they decided that it would be more likely to be generally convenient to members and secure better meetings. Although the alteration did not pledge the Council to call the meeting in any other town, he thought that the restriction which prevented them from doing so, if they saw good reason, was unnecessary.

Mr. H. B. NASH suggested that it would be desirable to leave the time and place of meeting to the Council.

The CHAIRMAN, after further discussion, moved that the rule read as follows:—"A General Meeting of the Institute shall be held in every month, except the months of January and June, and the Annual Meeting shall be held at such time and place as the Council may decide."

Thus amended, the alteration of rule was carried unanimously.

ELECTION OF OFFICERS FOR 1898-99.

The scrutineers reported the result of the election as follows:—

PRESIDENT:

Mr. WILLIAM HENRY CHAMBERS.

VICE-PRESIDENTS:

Mr. E. W. THIRKELL. | Mr. F. N. WARDELL. | Mr. J. R. ROBINSON WILSON.

COUNCIL:

Mr. H. S. CHILDE.
Mr. H. ST. JOHN DURNFORD.
Mr. C. C. ELLISON.
Mr. H. C. EMBLETON.
Mr. MATTHEW HALL.
Mr. J. L. MARSHALL.
Mr. J. MELLORS.
Mr. H. B. NASH.

The CHAIRMAN (Mr. G. Blake Walker) said that his last duty was to thank the Council and members of the Institute for the courtesy which they had extended to him during the two years that he had held the office of President, and to vacate the chair in favour of Mr. Chambers, whom they had been so fortunate as to secure for their President for the next term of office. He congratulated the Institute very heartily on having Mr. Chambers for President. He was sure that under Mr. Chambers' energetic guidance the Institute would have a prosperous period before it.

Mr. JOHN NEVIN said that they must thank the retiring President for the excellent manner in which he had performed the duties of his office during the past two years. The Institute had made steady progress under Mr. Walker's presidency, and at all times he had done whatever he could for the benefit of the Institute. He asked the members to pass a hearty vote of thanks to their retiring President.

The motion was carried by acclamation.

The CHAIRMAN said that he was very much obliged to the members for their cordial vote of thanks. They had all tried to do the best they could for the Institute, he thought that it had made satisfactory progress during the past two years, and trusted that it would go on doing so.

The PRESIDENT (Mr. W. H. Chambers) then took the chair, saying that he was deeply sensible of the great honour which the members had done him by electing him President of this important Institute for the coming term. He hoped, with the assistance of the Council working with himself, that they would do everything they could to increase the prosperity of the Institute and to extend its usefulness.

The annual dinner was held in the evening at the Queen's Hotel.

THE INSTITUTION OF MINING ENGINEERS.

STUDENTS' MEETING,

HELD IN THE ROOMS OF THE ROYAL SCOTTISH SOCIETY OF ARTS, EDINBURGH, AUGUST 17TH, 1898.

MR. CHARLES C. GREENE IN THE CHAIR.

The following paper, by Mr. G. C. Allsebrook, on "Coal-cutting by Machinery" was taken as read :—

COAL-CUTTING BY MACHINERY.

BY G. CLARENCE ALLSEBROOK.

In all industrial operations, the producer or manufacturer who can bring his goods on to the market most cheaply will secure the largest demand, always provided, however, that the quality is as good as, or better than, that of his rivals in the industry. For this purpose, machinery has been adopted in all industrial operations, and the industry of mining, on which so many of the great industries depend, has not been an exception.

Within comparatively recent years, machinery has been substituted for manual labour in nearly all the different branches of coal-mining. There are well conceived and well carried out arrangements for bringing the coal to the shaft-bottom, powerful winding-engines capable of rapidly drawing it from the bottom to the bank, numerous devices for picking, sorting, sizing and even washing it, and yet, although these are considered necessary to the very existence of every large colliery, the actual getting of the coal is carried on in the same way as it was before the name of machinery was heard of.

There must be some good reasons for this extraordinary state of things, and the most telling, perhaps, is that the need of machinery for coal-getting has not until now made itself very strongly felt ; and of almost equal importance is the fact, that although colliery-owners and

mining engineers might have been willing to use machinery, yet they were handicapped at the outset by the fact that there was no suitable power with which to drive it.

The Need for Coal-cutting Machinery.—However little need may have been felt in the past, there is no doubt that it is making itself keenly felt in the present, and it will perhaps be useful to look at some of the reasons for this :—

(*a*) Competition both at home and abroad is becoming more acute each year.

(*b*) The thick seams in this country are rapidly becoming exhausted, and we have to turn our attention to the thinner seams. These are almost invariably more expensive to work, for the simple reason that, for every certain amount of holing or other work done by the miner, he gets less coal: bearing about the same proportion to what he got formerly, as the thick seam bore to the thin seam.

(*c*) Following on this last, is the fact that the seams remaining to be worked will mostly be found at greater depths and consequently have higher temperatures.

(*d*) The natural and growing tendency on the part of the men to do less work, and that of a less laborious nature, than was done by their fathers, and, coupled with this, the demand for shorter hours.

(*e*) An increase in the demand for large coal, even at a higher price.

(*f*) The increase in the cost of getting, occasioned by the recent Explosives in Coal-mines Order. There is no doubt that, in many districts, this will be seriously felt, the men having in some places demanded as much as 3d. per ton more for getting, because of the order.

(*g*) And, finally, the Workmen's Compensation Act, which forces the colliery-owner to pay compensation for every accident with which the men in his employment may meet.

We will now examine how these points may be met by the introduction of coal-cutting machinery :—

(*a*) Is purely a question of cost. It has been proved in actual practice that, with the help of suitable machinery, coal can be got more cheaply than with hand labour only.

Mr. J. W. Galloway, of Trabboch colliery, Ayrshire, has recorded the following comparison between the cost of heading with the Stanley heading-machine and by hand :—

		s.	d.
Actual cost per yard for cutting mine, with machine	...	12	0
Estimated cost per yard for cutting mine, by hand ...	...	19	0

Where machines have been working in longwall-faces and comparative costs of getting have been ascertained, there seems to be a saving of from 3d. to 10d. per ton of coal in the actual getting as compared with hand labour; and a saving in increased value of coal yielded of from 6½d. to 10½d. per ton, making a total saving in favour of machinery of from 9½d. to 1s. 8½d. per ton. This saving, of course, varies with the nature of the holing, thickness of the seam, wages of workmen, etc.

(*b*) This is again a question of cost, differing from the former in that while one was a question between working at a large profit and working at a small profit, the other is often a question between working at a profit and working at a loss. It even becomes a question, in the thinnest seams, between working the coal at all and leaving it unworked, as thinner seams of coal can certainly be got by machinery than can be got by hand.

(*c* and *d*) A machine is neither acted upon by exhaustive temperatures nor by long hours, and although a man may not be equal to the arduous labour of under-cutting by hand at a high temperature, yet he may very well be able to guide the operations of a machine.

(*e*) The thickness of the cut made by a machine is seldom more than 4 inches, while that made by the miner must often be at least 12 inches. The machine, consequently, can get from under the same area of roof a much larger percentage of round coal than can be got by hand.

(*f*) The greater the depth to which holing can be carried, has a very marked effect on the number of shots necessary to bring down the coal. In experiments made on a longwall-face of 1,800 feet, it was found that with a cut 3½ feet deep, the number of shots required was 40, with a 5 feet cut 18, and with a 5½ feet cut only 3.

It is highly probable that, could the holing be carried to a depth of 6 feet or 6½ feet under, no explosives would be used. It will readily be seen that this saving bears on the question of cost, and the more important question of safety, as there is no doubt that could explosives be done away with in mines, a very fruitful source of accident would be removed at the same time.

(*g*) The lessening of the number of accidents by the elimination of explosives has already been mentioned. Faces which are being worked by machinery advance very much more rapidly than faces not being so worked, that is, if the arrangements for getting the coal down and out of the district are as they should be. This advance may be so rapid and regular as to ensure the miner being under a new roof each day.

The work of the coal-holer is a somewhat dangerous operation, and

more than half of the accidents occurring underground are due to falls of roof and side. Most of these accidents are caused by pieces of coal and of stone, which fall upon the miner either when he is holing or is in the bank.

When under-cutting by machinery, the miner will neither have to, nor will he be able to, hazard himself by getting under the coal, and falls in the bank will be largely done away with by the fact that he will constantly be working under a fresh roof.

Another minor point which must appeal to the colliery-owner is the fact that a given output of coal can be maintained with fewer men than formerly, and thus he will have considerably fewer men risking their limbs and lives in his employment.

Apart from the questions of the desirability of coal-cutting machinery from the owner's point of view, it may be useful to notice the effects which it may have upon the workman himself.

(*a*) *The Effect upon his Labour.*—The introduction of machinery will take away the very laborious task of holing, and put in its place the much easier work of managing the machine. The change will be from purely manual labour, generally of necessity wastefully applied, to a much higher form of skilled labour, in which the head will be needed more than the arms. Without doubt, the man will be the gainer by the change.

(*b*) *The Effect upon his Wages.*—The introduction of machinery has been accompanied in most industries by an increase in the wages of the workers. This is only natural, as a higher mental capacity is generally demanded by the new order of things, and this must be paid for; but at the same time, employers will more readily be able to pay higher wages. The writer sees no reason why an increase in wages earned by the miner should not accompany the use of machinery for coal-cutting.

(*c*) The effect upon the workman's safety has already been discussed.

(*d*) *The Effect upon the Number of Workmen employed.*—It has been stated that the introduction of coal-cutting machinery will be followed by an increase in the number of men employed. The reasons given for this conclusion are that although there may be fewer men employed in getting the coal, a large number of extra men will be employed in attending to machines, laying rails, setting timber, etc. It is quite true that at collieries where coal-cutting machinery is now being used, more men may be employed than were before its use, yet at the same

time, it is true that a larger output will be obtained for the same number of men employed, or the same output for a smaller number of men.

Looking at these facts, we see that although at one particular colliery more men may be employed, yet if all the collieries in the country used coal-cutting machinery the present output of coal could be maintained with fewer men than are now employed; or, if employment were still found for the same number of men, the output would be largely increased, and this increased output would only be useful if it were accompanied by a proportionate increase in the demand for coal either for household consumption, for manufacturing purposes, for use on railways or shipping, or for export. Unless this demand should take place, the adoption of coal-cutting machinery to any large extent will, in the writer's opinion, be accompanied by a decrease in the number of men employed.

Motive Power.—The second great hindrance to the use of machinery for coal-cutting was the absence of any suitable motive power. Even now, there is only a choice of three methods:—(1) Rope-gearing; (2) compressed air; and (3) electricity. Of these, rope gearing may be passed over as unsuitable for this class of work, leaving the choice between compressed air and electricity.

Compressed air is an uneconomical power, as from its compression there is continual loss, due to the friction in the pipes and leakage, and if we obtain 35 per cent. of useful effect, we may flatter ourselves that it is a very satisfactory result.

The efficiency of a good electrical plant may vary from 55 to 60 per cent.

Compressed air is a safe power, and can be used without inconvenience in either wet, dry, or fiery mines. In some cases, the noise made by the air at the motor is so great as to prevent other sounds from being heard, and this exposes the men who may be working the coal-cutting machine to extra risk.

Mr. T. B. A. Clarke, in a paper read before the Midland Institute of Mining, Civil and Mechanical Engineers, quoted figures showing what he considers would be the relative cost of the two systems.* The first cost of an electrical plant for a yearly output of 180,000 tons, he placed at £3,020, and the yearly working cost at £2,570, or 3·42d. per ton. The first cost of an air-compressing plant for the same output, he reckoned at £4,245, and the working cost at £3,790, or 5·05d. per ton.

* *Tran. Inst. M.E.*, vol. xi., page 492.

These figures show a saving of £225 on the first cost, or of 1·63d. per ton in favour of electricity.

Electricity is not a safe power on account of the sparking, which will always take place at the motor, and unless separate cables are used, it may take place anywhere along the wires.

The electric current should always be conducted in separate, as distinct from, concentric cables. Mr. Clarke in his paper gives his reasons for preferring to use separate cables. He says that although concentric cables are less trouble to put up and cost some 15 per cent. less than separate cables, yet the latter are preferable for the following reasons :—

1.—A short circuit is almost impossible, as the cables of opposite polarity can be kept any desired distance apart.

2.—Single cables are rapidly spliced and extended, and in the case of severe abrasion, reinsulated ; in many cases it would be impossible to repair concentric cable, and it would need to be returned to the cable-maker, causing thereby great expense and inconvenience.*

Of course, there are many mines which are so free from gas that mining engineers would have no hesitation in employing electricity as a motive power.

Method of Setting-out.—After spending a large sum in purchasing coal-cutting machinery, of course it is necessary that the machines shal be kept constantly at work. For this end some method of setting-out must be adopted, so that when a machine has completed the cut on one length of face, it may be conveniently moved to another, and that it may be kept at work whilst the coal in the former face is being got down and sent out and the face generally prepared for another visit from the machine.

A method which has been adopted, and found to answer very well indeed, is illustrated in the accompanying sketch (Fig. 1). Two headings are driven end and face, and the gate-roads are driven into the solid from these, the distance apart being 140 feet.

Coal-cutting Machines.

The essentials of a good coal-cutting machine are :—

(1) It must be as light as possible, so long as this is compatible with strength. It should be so light as to be able to be moved by two men working in a confined space, and also so as to be readily moved from place to place. Also, the lighter it is the more reasonable the class of rails which must be used, cutting down the expense in road-laying.

* *Tran. Inst. M.E.*, vol. xi., page 495.

(2) It must be as strong as possible. As the machine often has to stand rough usage, and is at all times liable to be injured by falls of roof and sides, it should be made of the very best material and workmanship, and all parts not in themselves strong must be carefully protected.

(3) It is often imperative that the space between the face and the timber or goaf shall be very narrow. For this reason the machine should be as narrow as possible. Added to this, the machine generally should be as small and compact as possible.

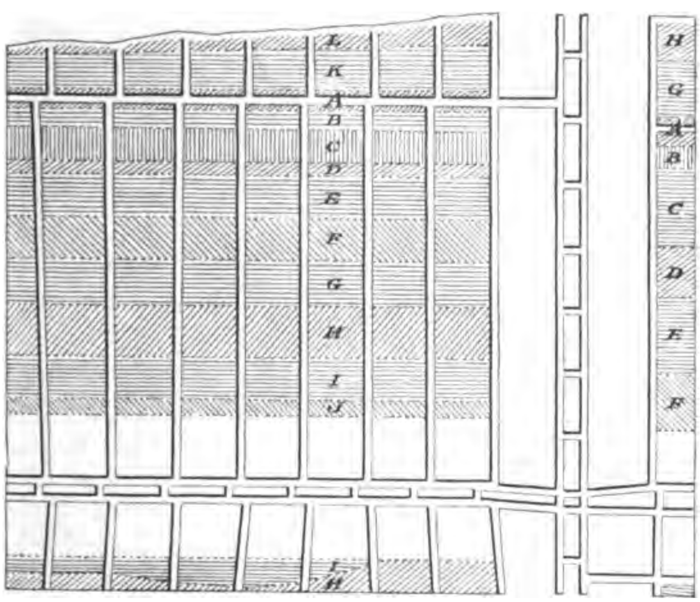

Fig. 1.—Scale, 400 feet to 1 inch.

(4) It should be so simple in construction as to be able, if possible, to be readily repaired in any small detail by the class of men who usually have the working of them, viz., the more intelligent miner. Again, the more simple it is in construction, the more easily can it be inspected. Complicated machines are always liable to break down and get out of order, and hindrances caused by continual stoppages of coal-cutting machines are both vexing to the management and bad for the mine.

(5) It should not be necessary to trim the floor, roof, or sides either before or after a machine, that is, it should cut into the face itself without the need of having to make a hole for it, and should clear its own cut, leaving the floor of the level ready for another cut.

(6) The cutting-tools should be simple, and so made that they can be readily fixed or taken out and easily sharpened.

(7) The machine should have a reserve of power over that required to cut in coal or fire-clay, so as to be able to cut through any obstructions or particularly hard substances which may be met with, such as iron pyrites, etc.

The machines now in use may be classed under five heads :—

(1) Core-cutting heading machines, (2) percussion machines, (3) chain machines, (4) rotary-bar machines, and (5) rotary-wheel machines.

Core-cutting Heading Machine.—The Stanley heading machine is the only machine of this class, and will be more fully described later on.

Percussion Machines.—The action of these machines bears some considerable resemblance to the miner with his pick. The work is done by a drill which works backwards and forwards at a great rate, striking the coal or other material at the end of each forward stroke. The machines are of comparatively small size and weight, and can be used in a very small place. They will cut in any direction, either horizontal or vertical, and can be used for any class of work, holing or shearing.

Chain Machines.—There are two classes of chain machines, those with the chain placed parallel to the machine and those with it at right angles. Of the various types of this machine, some can be used for longwall working and some for pillar and stall. The future of chain machines no doubt depends to a large extent upon the life of the chain, a point which has not, up to the present, been conclusively proved.

Rotary-bar Machines.—There are two classes of bar machines, one with the bar parallel to the machine, and the other in which it is at right-angles. The action of these machines is like that of a cross-cut saw, they cut across the grain of the coal instead of with it. The parallel-bar machine is not suitable for general use in longwall work, as it requires the timber to be set a considerable distance from the face ; it is, however, very suitable for heading work. The right-angle bar machine is suitable for longwall work. There is always a tendency, however, on the part of the bar machine, for the point of the bar to mount in the coal, especially if the coal in that portion be softer than in the portion where it is wanted to work.

Rotary-wheel Machines.—In this class, the cutters are fixed in the circumference of a wheel which is caused to revolve in a horizontal plane. The action of the wheel may be compared to that of a rip-saw, cutting the coal as it does, with the grain, and this seems to be by far the best

mode of attack. The chief objection to this type is the great weight of the wheel, which makes it awkward in transport. This difficulty may to a great extent be overcome by having the wheel made in two segments, to be fastened together by bolts. The wheel machine can only do good work in a comparatively straight longwall-face.

Core-cutting Heading Machine.

Stanley Heading Machine.—This machine, as its name implies, is used exclusively for heading. It is driven by compressed air, though it can be worked by electricity or rope-gearing, and consists of two vertical cylinders mounted at the bottom of a strong framework. By means of suitable gearing motion is transmitted to a central shaft, which has fixed to it a cutter-bar, formed of a strong casting of the same length as the diameter of the heading which it is proposed to drive. To this are fixed at the end horizontal arms carrying the cutters. The horizontal arms are usually from 3 to 4 feet long. As the shaft and arms are made to revolve, a circular groove 3½ inches wide is cut out, leaving a core which either breaks off or has to be got down as the work proceeds. The machine is worked by two men, one of whom regulates the pressure-handle and the other stands at the side and clears away the small coal and core. When a large core has broken off, or when the arms are engaged to the full depth, the shaft is run back and the machine removed while the core is cleared away. It is then run up to the face again, and the work proceeds as before. The rate of progress under favourable conditions is about 3 feet per hour; of course, the chief hindrance to more rapid working is the time that is taken to clear away the coal, the actual cutting being a much quicker performance. The roadway made by this machine is circular, and although this may be a strong form of roadway and suitable for ventilation, yet it is certainly not good for travelling or haulage. The machine will do good service where it is necessary to open out a colliery rapidly, particularly in pillar-and-stall work; or on a longwall working back, when the headings have to be driven to the boundary.

Percussion Machine.

Ingersoll-Sergeant Machine.—This machine is designed for bord-and-room work, but it is also suitable for narrow and heading work. It is comparatively light, weighing only 750 pounds, portable and cheap. It consists of a drilling machine mounted on a pair of wheels to enable it

to cut in any direction, and also to facilitate its removal from place to place. It is usually worked by compressed air, and has a cylinder about 4 inches in diameter. To the end of the piston-rod is attached an extension-head which receives the shank of the pick. The latter is made of forged steel, the cutting edge being in the shape of a V, having sharp edges and cutting points. This pick can readily be sharpened and kept in order by an ordinary blacksmith. The valves are so arranged that when the machine is beginning to hole, and is close up to its work, it will give a great number of light blows, and when the holing gets deep and the work more severe, the number of blows is lessened and the force increased. The machine is provided with large hub-bearings, intended to develop friction and so lessen the recoil. With this arrangement, even when the machine is making as many as 250 double strokes a minute, the recoil is only about ¾ inch. Handles are fitted with which the operator can direct and control the working of the machine. The machine, when at work doing under-cutting, is mounted on a platform of strong boards about 6 feet long and 3 feet wide, having an inclination to the face of about 6 inches. When it has holed all that can be done from one platform, it is moved forward 3 feet on to another platform, or else machine and platform are together moved forward. Two men are required to work it, the second being employed in removing the small coal from the cuttings. It is capable of cutting from 50 to 150 feet per day, and the depth of under-cutting may be up to 6½ feet. Very much like the Ingersoll-Sergeant are the Harrison and the Yoch machines, the latter being stronger and about 400 pounds heavier.

Chain Machines.

Mitchell Machine.—This is an American machine of recent invention, and specially designed for longwall working. It is worked by compressed air, and has two cylinders (6 inches in diameter and 8 inches stroke), carried on a frame 7 feet long by 2½ feet wide, the weight being about 4,000 pounds. It is so arranged as to propel itself along the face by means of a drum carrying a length of wire-rope, one end of which is secured to a prop set in front of the machine. A bar carrying the cutting-chain projects from the machine at right angles, the cutters being fixed into the links of the chain. Motion is transmitted to the chain by spur-and-bevel wheels, the gearing running in oil. The depth of the cut is about 3½ feet and the height 3½ inches. More than a maximum cut of about 200 feet to a depth of 5 feet under per day of 8 hours cannot be done, owing to the chain becoming heated. The

machine is compact and will pass through an opening 3 feet high and 2½ feet wide, and it will also cut with ease if the timber be set not less than 4 feet from the face. Two men are employed to look after the machine, one to look after the machine itself and the other to clear away the small coal.

Jeffrey Chain Machine.—This machine will work either in pillar-and-stall or longwall workings. It is built in two styles, differing only slightly from one another, one being driven by compressed air and the other by electricity. The machine consists of three principal parts, the bed-frame, the sliding chain-cutter frame, and the motor-carriage. The bed-frame consists of two rectangular steel channel-bars and two steel angle-bars fastened together by braces. Upon this are mounted the feed-racks, and a cross-bar on which rests the jack for taking the backward thrust. The cutter-frame consists of one steel centre-rail, the cutter-head, and two side-guides for the cutter-chain. The cutter-frame is triangular in shape, making it necessary to use only three wheels, two in the cutter-head and the sprocket-wheel for conveying power to the cutter-chain. The driving and feeding mechanism, consisting of steel pinions and wheels for driving the machine, is mounted on the carriage of the machine. The cutter-bits which are fixed in the ends of the cast-steel cutter-links are straight, with a slight hook at the cutting-end, and may be sharpened many times, allowing as much as 75 per cent. of the steel in each bit to be used.

The method of working is as follows:—The machine is hauled to the face of the coal on a specially designed truck running on the ordinary tram-rails. Having reached the place where work is to begin, it is slid off, connexion is made with the motive power, the machine is firmly fixed in position and it is ready to start. When it is set working, the chain begins to travel round, doing the cutting, while at the same time the cutter-head and frame are advanced into the coal. Having cut into the full depth of the cut, the direction of travel is reversed and the cutter-frame drawn in again. The machine is then slid along a distance about equal to the length of the cutter-head and the work proceeds as before. The machines are built to undercut 5½ and 7 feet, the width of the cut being 3⅝ feet, and its height 4 inches. Two men are required to work it, and will cut about 100 feet in length per shift in a 30 inches seam of coal, though as much as 300 feet, cut to a depth of 5½ feet under, have been cut in 10 hours.

Rotary-bar Machines.

Goolden Machine. – The undercutting is done by a tapered bar about 5 feet long, fitted with a number of V-shaped cutters driven into tapered holes. The cutters are arranged in the form of a spiral, so that the bar in working brings all its small coal out to the face. The whole of the cutting mechanism is arranged on a turntable which is capable of being moved through an angle of about 90 degrees on its upper side. This is a very useful arrangement, allowing as it does:—(1) The bar to be brought underneath the framework for transport of the machine; (2) the bar to be made to cut its own way into the coal; and (3) the bar to be withdrawn at any part of the cut for examination. In the case of a cutter getting broken, this is very important.

The motive power is electricity, and motion is transmitted to the bar by two cast-steel helical wheels running in oil. The number of revolutions of the bar varies according to the nature of the material to be cut, and ranges from 300 to 500 per minute. The motor is protected by a strong metal casing, and the armature and commutator are placed in a dust-and-flame-proof compartment. A small drum is placed on the front of the framework, and is made to revolve by an arrangement of clutch-and-wheel work in connexion with the motor-shaft. From this drum is carried a length of wire-rope, which passes round a pulley at the end of the cut and back to the arm in front of the machine. The drum when made to revolve winds up this rope, and so compels the machine to move forward along the face. The speed can be regulated as required, irrespective of the rate of working of the machine.

Heppell and Patterson Machine.—This machine is similar in principle to the last. The cutting-bar has three dovetailed grooves along its length in which the cutting teeth are placed. They are kept in position and at the right distance apart by strips of metal. The teeth may be thus arranged in any way which may be considered advisable. The bar is held in position by a bracket at the far end, and the whole of the cutting parts can readily be swung round for examination of the bar or removal of the machine. The small coal is brought out by an endless scraper-chain which is protected from injury, by the coal sinking down upon it, by a strong metal guard. The machine is electrically driven, motion being given to the bar by cast-steel bevel-wheels and pinions. The motor and all the working parts are protected from injury by a strong metal casing having the necessary hand-and-sight holes for examination and repairs. The machine is mounted upon wheels which travel on rails, and is fitted with the usual

adjustable self-propelling arrangement. It is claimed for this machine that, in consequence of the work done by the scraper-chain, much less power is required than in other machines of the same type, in which the small coal is liable to clog in front of the bar.

Jeffrey Rotary-bar Machine.—The action of this machine is very much like that of the Jeffrey chain machine already mentioned, except that in place of an endless chain, is substituted a revolving-bar, which has motion transmitted to it by a chain. The cutter-bar, which is about 40 inches wide, is fixed at the front of a sliding frame and is held in position by two steel shoes and brasses. It is fitted with cutting-teeth, which are made of the best tool steel and are kept in position by set-screws. The driving-chain is an endless curved-link steel chain taking its motion from the driving-shaft. As the under-cutting proceeds, the bar and chain are advanced into the coal or other material to be cut, up to 5 or 7 feet. The small coal and cuttings are brought out by means of light scraper-chains. The motive power may be either electricity or compressed air, in the latter case the machine will have two cylinders, each 5 inches in diameter and 5½ inches stroke, except in cases where very heavy work has to be done, when the cylinders may be 6½ inches in diameter by 5 inches stroke.

The method of working it is almost exactly the same as that adopted with the Jeffrey chain machine. The time taken to make a cut is from 4 to 6 minutes. If electricity be used instead of compressed air, the place of the cylinders is taken by an electric motor. The current varies from 30 to 50 ampères, and at a pressure of 220 volts this will develop up to 15 horsepower. The number of revolutions made by the armature is about 1,000 per minute, and that by the cutter-bar about 200. In some tables given by Mr. R. M. Haseltine, chief inspector of mines for Ohio, U.S.A., he shows a comparison between the results obtained by using a Jeffrey chain machine and a Jeffrey bar machine. The chain machine had a decided advantage over the bar type, so far as rate of working is concerned. The average electric horsepower is only a little over half that required for the bar machine, while the time taken for each cut is only about three-quarters of that required for the bar machine, the amount of coal under-cut being practically the same in each case.

Hurd Electric Machine.—The machine is of the right-angled bar type, with cutters arranged spirally on the bar, which tapers from the machine to the outer end. In recent trials, the machine worked on a face about 330 feet long, the under-cutting being carried to a depth of from 3 to 4 feet, and the average time taken for cutting this face was

$4\frac{1}{2}$ hours, including stoppages. The actual cutting speed is over 2 feet per minute, and the average speed, counting stops, about 70 feet per hour. The cuttings are automatically cleared away. A feature of this machine is the universal cutting-end, by means of which the cut can be made either to the right hand or left hand, and at any height in the seam. The machines are made in three sizes, weighing 20 cwts., 28 cwts. and 55 cwts., and capable of under-cutting from 3 to $5\frac{1}{2}$ feet. The machine is well protected from injury, and is fitted with the usual automatic-feed arrangement.

Rotary-wheel Machines.

Gillott and Copley Machine.—This is without doubt the best known of the type, having been in actual working for more than 20 years. The machine is made in three sizes. In the largest machine, the cutter-wheel is 4 feet 1 inch in diameter, and is carried by a steel bracket, which projects horizontally from the side of the machine. This machine, which is worked by compressed air, has a frame about $5\frac{1}{2}$ feet long by 28 inches wide, and carries two cylinders, each 9 inches in diameter and 9 inches stroke. The connecting-rods work on to a crank-shaft, driving the pinion, which in turn gives motion to the cutter-wheel. The cutter-wheel carries on its circumference about 25 steel teeth, and makes about 6 revolutions per minute. The machine is capable of cutting to a depth of $3\frac{1}{2}$ feet, the height of cut not exceeding 3 inches. As the direction of the cut is from back to front, all the cuttings are brought out by the cutters. The machine runs along rails by the face-side, and the feed is regulated by the usual wire-rope and pulley arrangement. The great fault of this machine had been that it did not cut level with the floor, which, in consequence, has always to be taken up by hand. It is now arranged so as to cut level, but in this case must be provided with a guard to keep the wheel from taking the cuttings back into the holing.

Pope and Pearson Machine.—In this, another of the rotary-wheel type, the frame is $8\frac{1}{2}$ feet long by $2\frac{3}{4}$ feet wide, and is provided with wheels. The machine is worked by compressed air, and the cylinders, each $9\frac{1}{2}$ inches in diameter and 9 inches stroke, are placed at either end of the framework. This arrangement has an important effect in balancing the large cutter-wheel. The cutter-wheel, which is 5 feet 8 inches in diameter, without cutters, and 6 feet 4 inches with cutters, is carried by a triangular bracket fastened to the frame. The speed of the engine to the cutter-wheel is reduced in the proportion of 22 to 1, the

wheel when at work running from 7 to 8 revolutions per minute. The depth of cut is 5½ feet under, by from 5 to 6 inches high, this being by far the deepest cut yet made with a rotary-wheel machine. The roadway consists of strong flat-bottomed rails, which are laid on special sleepers. The machine is worked by three men, who manage the machine, clear away the cuttings, sprag the coal, and do the necessary road-laying. About 800 feet have been cut in 16 hours 40 minutes, or at the rate of 374 feet per shift of 8 hours. A peculiar arrangement in this machine is that by fitting on an extra pair of axles and wheels and turning the machine over, it can be made to cut at any height in the seam. There is little doubt that this is one of the very best, if not the best coal-cutting machine at present in the market.

Scott and Mountain Machine.—This is another of the rotary-wheel type and is to some extent compounded of the principles of the Rigg and Meikeljohn on the one hand and of the Gillott and Copley on the other. The motive power is electricity, the motor being placed at about the centre of the framework. The latter is 7¾ feet long, 40 inches wide, 23 inches high, and is mounted on double-flanged wheels which may be gauged to suit any size of roadway. The motor runs at a speed of 600 to 700 revolutions per minute, producing 12 effective horsepower. Motion is given to the cutter-disc, which runs at a speed of about 25 revolutions per minute, driven by means of spur-wheels and worm-gearing. The disc is carried on a bracket so arranged that the cut is made on the floor-level. It is 3½ feet in diameter, will cut to a depth of 3 feet, with a height of 3½ inches, and has 20 steel cutters arranged around the edge of the disc. These teeth are so arranged that the wheel may be run so as to cut in either direction.

A larger machine, very much like the last, fitted with a motor developing 25 effective horsepower, will cut up to 4½ feet under. In this machine, motion is given to the cutter-wheel by spur-gearing only, the worm-gear being done away with. The total height of the machine is 17 inches, thus making it very suitable for use in thin seams. In both machines, the working parts are protected by strong steel casings fitted with hand- and sight-holes. The ordinary automatic-feed arrangement is used. Two men are required to work this machine, one to work the switches and the other to clear away the cuttings, a third man being required to assist in road-laying.

Jeffrey Electric Longwall Machine.—This is another rotary-wheel machine, which has been brought out lately. The width, without the wheel is 3 feet 8¾ inches, and the length 8 feet 2 inches. The depth of

under-cut may vary from 3 to 6 feet, the height of cut varying from 4 to 6 inches. The gearing to operate the cutting-wheel and feed, which is of the ordinary type, is so arranged that it may be run in oil. The feed is so arranged that the machine will cut at three speeds, namely, 25, 16 and 8 inches per minute. These alterations in speed may be easily accomplished whilst the machine is in motion. The peculiar feature of this machine is that one rail only is used, as when two rails are used, the machine often leaves the rails, but with the whole weight of the machine resting on one rail, the difficulty is largely overcome. There are two wheels on which the machine runs, one being in front and the other at the back. At the front end, there is an "idler" wheel which takes the side-thrust due to the pull of the cutter-wheel.

A vote of thanks was accorded to the Royal Scottish Society of Arts for the use of their rooms for the meeting; to the Fife Coal Company, Limited, for permission to visit their collieries; and to the local committee of the Mining Institute of Scotland, who had made the arrangements for the meeting.

The following notes record some of the features of interest seen by visitors to collieries and works, which were, by kind permission of the owners, opened for inspection during the course of the meeting on August 17th, 18th, and 19th, 1898 :—

DALBEATH COLLIERY.

The pit is 26 feet long by 11 feet wide. There are two engines winding from this shaft: No. 1 from the Dunfermline Splint coal-seam at a depth of 984 feet, and No 2 from the Glassee coal-seam at 780 feet.

The No. 1 pit winding-engine has two cylinders, each 28 inches in diameter by 5 feet stroke, fitted with a cylindrical drum 14 feet in diameter by 8 feet wide. The winding-rope is $1\frac{1}{8}$ inches in diameter. The cages have two decks, and carry two hutches on each deck. The weights lifted are :—cage, 37 cwts.; hutches, 19 cwts.; and coals, 39 cwts., a total of 95 cwts. The hutches are pushed into the cage (on the surface) by means of steam-rams.

The No. 2 pit winding-engine has two cylinders, each 24 inches in diameter by 5 feet stroke, fitted with a cylindrical drum 12 feet in diameter by 8 feet wide. The rope is $1\frac{1}{8}$ inches in diameter. The cages are single-decked, carrying two hutches, end to end.

There are eight Lancashire boilers, 30 feet long by 8 feet in diameter, working at a pressure of 80 pounds per square inch; seven of the boilers are fitted with Meldrum forced-draught furnaces, and are fired with duff or coal-dust.

The hauling-engine has two cylinders, each 16 inches in diameter by 4 feet stroke, the shaft is geared 1 to 7 and carries a clip-pulley (7 feet in diameter) driving a band-rope (1 inch in diameter) for underground haulage, and a Clifton wheel driving a three-throw pump for feeding boilers, and a creeper for empty hutches at the pit-head. The band-rope drives a shaft at the pit-bottom, having on it a clip pulley (7 feet in diameter) and a Clifton wheel (7 feet in diameter). These pulleys are moved in and out of gear by gearing actuated by friction-clutches. The clip-pulley drives the main haulage-rope, which passes down the main dook, dipping at a gradient of 1 in 29½ for a distance of 1,380 feet, then along a level for 990 feet in the same line as the dook. The same rope also passes down a side dook, leaving the main dook at about 1,250 feet from the pit-bottom, for a distance of 470 feet, at a gradient of 1 in 28, then turns to the right and travels 700 feet further, at a gradient of 1 in 14. The total length of rope on this haulage is about 7,110 feet. The rope runs under the hutches, which are brought out by bogies attached to a train of from 12 to 16 hutches. The Clifton wheel drives a haulage in a road about 900 feet long: half of this length is level from the pit-bottom, and the remainder dips at a gradient of about 1 in 5.

The vertical compound pumping-engine has a high-pressure cylinder 57 inches in diameter by 8 feet stroke, a low-pressure cylinder 84 inches in diameter by 12 feet stroke, and a pumping stroke of 13 feet. Both of the piston-rods and the pump-rods are attached to a beam placed under the floor-level. The pump-rods are attached to one end of this beam, and a balance-box at the other end contains weights equal to one half of the weight of the rods.

The underground pumps comprise a Davey hydraulic pump situated 1,500 feet from the pit-bottom, and delivering into the main lodgment at the shaft a vertical distance of 58 feet; and an Evans hydraulic pump delivering to the Davey pump at a distance of 900 feet from it, and a vertical distance of 65 feet. These pumps are worked from the pressure of a column of water in 3 inches pipes, which extend from the pumps to the pit-bottom and up the shaft to the surface, giving a head of 1,041 feet at the first pump. There is also a rope-driven pump, worked from pump-rods, situated 810 feet from the pit-bottom and pumping into the main lodgement.

There are three main picking-tables. The coals are tipped on to a jigger-screen, having holes 2¼ inches in diameter. They then pass along a picking-table 4 feet wide, and after the rubbish is picked off by hand, are passed into waggons. If "chirls" are required, the coals pass over a shoot, having bars spaced 3 inches apart, after passing over the picking-table. These bars are covered over, if not required for "chirls." Small tables or travelling-bands carry the "chirls" back under the main table to an adjacent road, where they drop into waggons. The small coal which passes through the jigger-screen passes down a shoot into a well, whence it is lifted by an elevator and emptied into a long jigger-screen 32 inches wide, in which it passes through:—(1) A wire-mesh of 16 holes per square inch, forming duff; (2) a plate perforated with holes ¾ inch in diameter, forming peas; (3) a plate with holes 1 inch in diameter, forming single nuts; (4) a plate with holes 1⅝ inches in diameter, forming double nuts; and the coal which passes over all forms treble nuts. The duff, peas and single nuts pass directly into hoppers, from which they are loaded into waggons. The double and treble nuts pass over a picking-table, and thence into hoppers. There are three small-coal jigger-screens fed by two elevators.

The Waddle fan, 27 feet in diameter, at 60 revolutions per minute produces 50,000 cubic feet of air per minute under 1·25 inches of water-gauge.

MOSSBEATH COLLIERY.

There are two pits, 45 feet apart: the No. 1 or downcast pit being 14 feet long and 6 feet wide, and the No. 2 or upcast pit is 10 feet square. The No. 1 pit winding-engine has two cylinders each 21 inches in diameter by 4½ feet stroke, and a drum 12 feet in diameter. Two hutches are drawn in a double-decked cage weighing, with coals 20 cwts. and rope 19 cwts., about 64 cwts. The No. 2 pit winding-engine is of similar dimensions, fitted with a drum 14 feet in diameter. The single-decked cage carries two hutches, end to end, and weighs, including coals 20 cwts. and rope 19 cwts., about 62 cwts.

The Waddell fan is 15 feet in diameter, and exhausts 50,000 cubic feet of air per minute under 1·65 inches of water-gauge at 70 revolutions per minute.

The Moore hydraulic pump comprises an engine with a cylinder 24 inches in diameter by 4 feet stroke. By spur-gearing, 1 to 6, it drives a double-acting ram pump up to a pressure of 1,300 lbs. per square inch,

The underground pump is double-acting, fitted with power-rams 5 inches in diameter, forcing-rams 14 inches in diameter, and delivers 312 gallons of water per minute against a head of 390 feet.

There are five Lancashire boilers, 30 feet long by 7½ feet in diameter, working at a pressure of 100 pounds per square inch. An apparatus is used for softening the feed-water with the object of preventing incrustation on the plates of the boilers.

The hutches from each pit pass over a turntable steelyard to the various revolving tipplers, whence they gravitate to a self-regulating steam-hoist lifting to a height sufficient to permit of the hutch completing the circuit to the pit by gravitation.

A full description of the pithead arrangement is contained in Mr. W. H. Mungall's paper recently printed in the *Transactions.**

KIRKFORD PIT, COWDENBEATH.

This pit is 20 feet long by 11 feet wide, and passes through the Lochgelly Splint coal-seam at 1,044 feet, the Five-feet coal-seam at 1,356 feet, and the Dunfermline Splint coal-seam at 1,398 feet.

The winding-engines have two cylinders, each 30 inches in diameter by 6 feet stroke, fitted with a cylindrical drum 16 feet in diameter by 7¾ feet wide, steam reversing-gear and foot-brake. The double-decked cages carry two hutches on each deck, end to end ; the weight at the lift comprises:—Cage, 39 cwts.; hutches, 19 cwts.; coals, 42 cwts.; rope, 30 cwts., and a total of 130 cwts.

The double-acting vertical compound pumping-engine has a high-pressure cylinder 52 inches in diameter, and a low-pressure cylinder 90 inches in diameter by 12 feet stroke, working two sets of rods and rams in the pit, with a stroke of 12 feet.

There are six Lancashire boilers, 30 feet long by 8 feet in diameter, working at a pressure of 100 pounds per square inch.

The underground appliances include a Stanley coal-heading machine, 5 feet in diameter, in the Lochgelly Splint coal-seam, driven by compressed air; and a few haulers and small pumps used in dip workings, also driven by compressed air.

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* *Trans. Inst. M.E.*, vol. xiii., page 227.

AITKEN PIT, KELTY COLLIERY.

The Aitken pit is a downcast and winding shaft, the area within the lining being 27 feet by 11 feet. It is lined with pitchpine planks 11 inches deep and from 3 inches to 6 inches thick, and cross-buntons (pitchpine) 10 inches by 5 inches, placed 7 feet 10½ inches apart, arranged in three rows. The pitchpine conductors, 5 inches by 4 inches, and four to each cage, are bolted to the cross-buntons. The following are the workable seams:—

Name of Coal-seam.	Thickness of Coal. Ft.	Ins.		Depth from Surface. Ft.	Ins.
Main	5	8	...	696	0
Upper Jersey	4	2	...	714	0
Lower Jersey	5	8	...	726	0
Bank or Lochgelly Splint	5	6	..	831	0
Lochy or Glassee ...	4	6	...	960	0
Five-feet or Hartley ...	5	2	...	1,147	7
Dunfermline Splint or Aitken Wallsend ...	4	2	...	1,220	4
Bottom of Lodgement ...	—		...	1,244	9

The compound pumping-engine has a high-pressure cylinder 57 inches in diameter by 9 feet 6¾ inches stroke, and the low-pressure cylinder is 84 inches in diameter by 13 feet stroke. The low-pressure piston-rod works downward, and is connected to the fore-end of the main beam; and the high-pressure piston-rod also works downward, and is also connected at a distance of 10 feet from the fore-end of the main beam. The main beam, placed underneath the engine, is 60 feet long, and weighs about 75 tons. The back end of the beam is loaded with about 100 tons of metal. The beam-shaft is 21 feet long and 17 inches in diameter, and the air-pump is worked by levers keyed upon this shaft. The weight of pump-rods, rams, buckets, etc., is about 167 tons. The pumping-engine at present is only working a 12 feet stroke, and at a rate of 3½ strokes per minute takes away the growth of water or about 1,260 gallons per minute.

The winding-engine, with two horizontal cylinders, each 28 inches in diameter, by 5 feet stroke, is fitted with two cylindrical drums, 21 inches apart, 16 feet in diameter, and 3½ feet wide. There are four tubs on each cage, all on one deck, each tub carrying 10 cwts. of coal; an empty tub weighs 5 cwts., cage weighs 50 cwts., and winding-rope (1½ inches in diameter) in shaft weighs 40 cwts., making a total load of 150 cwts. There is a balance-rope, of the same weight as the winding-rope, working below the cages. The pit-head frame is made of steel, and is 60 feet high, the pulley-wheels being 14 feet in diameter.

The Walker ventilating-propelling fan, 16 feet in diameter, is driven by two grooved pulleys and cotton ropes, and forces 100,000 cubic feet of air per minute, under 1·75 inches of water-gauge, at 120 revolutions per minute of fan, and 30 revolutions of the engine.

The electric-lighting dynamo is compound-wound for 120 ampères at 100 volts, at a speed of 680 revolutions per minute.

There are ten steel Lancashire boilers, 30 feet long by 8 feet in diameter, built of $\frac{7}{16}$ inch plates in entire rings, double riveted, working at a pressure of 100 pounds per square inch. The chimney is circular, and 160 feet in height, and 9 feet in internal diameter. The boilers are fed by two live-steam injectors, through an economizer, thereby heating the water to 260° Fahr.

The pit-bank is 23 feet above the railway, and the wooden flooring is supported by steel girders of H section, and brickwork. Four jigging-screens are erected for large coal, and two others for dross. There is a power-driven tippler at each of the large coal-screens; the tippler places the coal upon a jigging-distributing plate, it goes thence to another plate which takes out the dross, while another perforated plate takes out the chirls, the large coal passing over to the main picking-table of the cross-bar type. This table is 36 feet long, and 14 feet of its length can be raised or lowered to suit the loading of the trucks. The chirls fall upon a conveyor, by which they are taken to a bar-picking table 16 feet long, for cleaning and discharging into trucks. The dross is taken by a close conveyor, 84 feet long, to two jigging-screens of three meshes, on which the coal is separated into duff, single, double and treble nuts. The double and treble nuts each fall upon a picking-bar table, 20 feet long, on which they are cleaned and delivered into trucks. The duff-conveyor travels under and across the whole of the picking-tables, collecting the duff at each table, and then turns at right angles to the boilers, its total length being 206 feet. The whole of the jigging machinery, etc., is driven by an engine with a cylinder 24 inches in diameter by 4½ feet stroke.

The longwall system is adopted here for working the coal; a longwall level about 45 feet wide is first driven, and at intervals of 45 feet a wheel-brae is branched, and the coal is all worked up the hill by these braes or inclines. After these inclines have ascended 250 or 300 feet, another level is made and these inclines are formed again. One of these inclines, at a distance of 300 feet or so, is kept to run the coal from the rise sections down to the main levels; also headings running across the rise from near the pit-bottom, cut off the levels to the rise and bring

the coal to the pit-bottom. No coal is left in the waste, and the roof is supported by material from the brushing and wooden pillars.

The haulage is all effected by horse and self-acting inclined-planes, but an endless-rope haulage is being erected for the dook-workings.

CO-OPERATIVE PUBLIC HOUSE AT HILL OF BEATH.

The house was bought by the Fife Coal Company, Limited, and the villagers' committee, who manage the public house, pay rent for it. The committee is composed of the manager of the works, a secretary and three others, who must be resident in the village. The licence is taken out in the name of the secretary, who buys all the liquors. The profits, which are about £500 a year, are applied in various ways for the benefit of the villagers:—A reading-room and a recreation-room have been established; recently the streets of the village have been lighted by electricity at a cost of £400; a bowling-green is about to be provided at a cost of £350; and the erection of a small hospital is contemplated, with the services of a trained nurse.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE ROYAL VICTORIA STATION HOTEL, SHEFFIELD, OCTOBER 29TH, 1898.

MR. W. H. CHAMBERS, PRESIDENT, IN THE CHAIR.

The PRESIDENT, referring to the sad loss that the members had sustained by the death of Mr. A. M. Chambers, a Past-President of the Institute, said that Mr. A. M. Chambers' abilities were recognized in many spheres, but in none so much as in the coal trade, as owner and engineer. He was called upon to preside over and direct meetings which were held from time to time for dealing with mining legislation, the working of collieries, and the settlement of wages, which were of the utmost importance to their great industry. He moved that—

The death of Mr. A. M. Chambers, a Past-President, and one of the most eminent members of this Institute, having come to the knowledge of the Council and members, they, at their meeting to-day, desire to express to Mrs. Chambers and family their deepest sympathy in the sad and irreparable loss which they have sustained, and to express their sense of the value of his services to this Institute.

MR. H. ST. JOHN DURNFORD (Acton Hall colliery), in seconding the motion, said that he had known Mr. Chambers personally for nearly 20 years, and had found him a most able, kindly and honourable gentleman.

The resolution was carried in silence, the members rising in their places.

The minutes of the previous General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. J. T. MINNIS, Colliery Manager, Oughtibridge, Sheffield.

Mr. ARTHUR THOMAS ROSE, Mechanical Engineer, Bugdanhtee Colliery, Danboom District, East India Railway, Bengal, India.

Mr. HUGO ROSSNER, Colliery Manager, Hohenegger Schacht, Karwin, Silesia, Austria.

The PRESIDENT (Mr. W. H. Chambers) delivered his inaugural address as follows :—

PRESIDENTIAL ADDRESS.

By W. H. CHAMBERS.

In the first place, I thank you for bestowing upon me what I esteem to be the highest honour that can be conferred by mining engineers on a member of their profession in electing me to act as President of this Institute for the next year. In accepting the position which I am so proud to occupy, I feel the deep responsibility attached to it, but relying upon the assistance of the Council, Members and Secretary, I have good hope that the period of my office will be marked by a continuance of that active interest and augmented usefulness which has been so well furthered by the skill and diplomacy of my distinguished predecessors.

Many Presidents, in the past, have expressed difficulty in stating in a Presidential address anything new or interesting and yet suitable, for no less than six addresses appear in the *Transactions* of The Institution of Mining Engineers every year, and consequently every possible subject connected with mining, well up-to-date, is commented upon. Whilst I am sincerely desirous of avoiding any subject tending to the criticism of political measures or legislation, the passing of the Workmen's Compensation Act, which came into operation this year, dealing with one of the great objects of the Institute, viz. :—the safety of the workmen employed in mines, justifies, I think, a consideration of the effect which it is possible to exercise in inducing the application of still more care and ingenuity, not only in the cause of humanity, but also in order to avoid heavy pecuniary loss. Many collieries at the present time are strained to their utmost resources to earn a moderate profit, whilst others only require the proverbial straw to complete their ruin. The effect of the Government measure cannot be at present estimated, but it is obvious that every possible effort must be made to minimize the liability of claims for compensation.

Hitherto Parliament, in the Mines Regulation Acts, rather followed the practice of the best collieries, sparing no expense in the employment of highly educated and experienced men in the management and the use of the best appliances of all descriptions tending to the safety of the mines and those engaged therein. The comparative safety thereby attained has without doubt been largely attributable to the efficient

system of inspection introduced on the passing of the first Mines Act in 1848 and subsequent statutes, and the facility afforded by the papers and discussions of the various Mining Institutes for managers to adopt the best approved or suggested means to decrease the liability to accidents. This object has been also furthered by mine-owners who, owing to the increasing depth of the seams and the consequent concentration of a large amount of capital in single undertakings, have become extremely anxious to take every precaution to avoid accidents which, if of large magnitude, would entail almost absolute ruin upon many of them ; also if minor accidents are extraordinarily numerous, there is difficulty in obtaining workmen under the risky conditions, entailing the payment of enhanced wages, all being adverse to economy and profitable working. The Mines Regulation Acts were obviously indispensable to prevent impecunious or speculative individuals, who have all to gain and little to lose, running inordinate risks for the sake of a larger and quicker profit.

In order to note the effect of the various means adopted to enhance the safety of miners, we may refer to the Government returns, and find in 1851, being the first year after the first Mines Act was passed (except the 1848 Act, which principally dealt with the employment of women and girls) that the number of persons employed in coal-mines above and below ground was 216,217, and the deaths by accident 984, equal to a death-rate of 4·551 per 1,000 persons employed. The proportions of deaths by explosion of fire-damp, falls of roof and sides, and miscellaneous accidents were about equal, being 321, 327, and 326 respectively. In 1873 and since, the returns include ironstone, oil-shale and fire-clay mines, with coal-mines. In 1897, the number of persons employed about coal-mines was 547,203, or 93½ per cent. of the total mining population, and of these it appears about 80 per cent. work underground. An official report just made by Prof. Le Neve Foster shows that in 1897 there were 897 separate fatal accidents in mines, which caused the loss of 979 lives, no separate accident causing more than 10 deaths. The death-rate for the last 7 years per 1,000 persons employed is as follows:—For 1891, 1·493 ; 1892, 1·480 ; 1893, 1·565 ; 1894, 1·587 ; 1895, 1·494 ; 1896, 1·467 ; and in 1897, 1·343, being the lowest on record, one-half of the deaths being due to falls of roof and sides. Explosions of fire-damp and coal-dust caused 1·9 per cent. of the deaths. Accidents on the surface contributed about 10 per cent. of the total. It appears that "not a single fatal ignition of gas or coal-dust can with certainty be ascribed to the flame of an explosive in shot-firing." In at least two cases, the explosion has been traced to the exposition of a naked light.

Quoting still from Prof. Le Neve Foster's return, from 1873 to 1877, the death-rate per 1,000,000 tons of mineral raised was 7·555; from 1878 to 1882 it fell to 7·295; from 1883 to 1887 it was 5·856; from 1888 to 1892 it was 5·471; and from 1893 to 1897 it was 5·184. These statistics show how greatly the lot of the miner has been ameliorated. The Mines Regulation Acts now provide every possible precaution that can be taken for his safety, regardless of cost or convenience.

The first principle in mining must be safety, and the next profitable working. Adequate Government inspection is provided, and all causes of serious accident are investigated by H.M. inspectors of mines. Managers and under-managers must prove themselves properly qualified, and exercise daily supervision of the mines. The employment of boys, girls and women is regulated as to age and period of work. Duplicate communication is provided from the mine to the surface. Ventilation and appliances must be adequate. Rules are in force for careful and constant examination of all working-places, roads, shafts, ropes, guides and machinery. All dangerous places and machinery must be fenced. Naked lights are prohibited where danger may be apprehended. Safety-lamps, capable of standing tests of almost impossible occurrence in actual use, are to be carefully cleaned, examined and locked, and must not be opened in the workings. Almost prohibitive restrictions are placed upon the use of explosives, so as to cause their discontinuance in every mine where it is possible to do without them. Every possible care is to be exercised in approaching old workings. Refuges are to be provided on underground roads where persons are liable to injury by passing trains, at stipulated distances. Horse-roads must be sufficiently high and wide to clear. Shafts must be lined. All roofs and sides of roads where persons pass are to be made secure. Sufficient timber for all requirements is to be near at hand for use when wanted. Enginemen are to be of stipulated age and competent. Proper signals in shafts from surface to bottom and bottom to surface, and on haulage-roads must be provided. Some approved contrivance must be attached to the engine or cages to prevent over-winding. Cages must be covered, single-linked chains are not to be used in shafts, and drums must be flanged and provided with adequate brakes where men ride. Boilers must be cleaned within stated periods, and be fitted with steam-gauges, safety-valves and water-gauges. Barometers and thermometers must be placed in positions where all employed may see them. All examinations must be recorded in books accessible to all parties interested. Workmen are allowed to make

inspections themselves. No collier must work alone, except after 2 years' experience. Special rules must be established at every mine for the guidance of all persons, both officials and workmen, engaged thereat, and as these rules are first to be proposed by the owners assisted by their mining engineers and managers; and in practice amended and approved by the miners' representatives; then by H.M. inspectors before final approval by the Secretary of State, I think I am fully justified in venturing the opinion that every possible means and care has been taken for the safety of those employed in and about mines by statute guided by the greatest available experience and knowledge of all classes connected with the business of mining.

Parliament having done everything it could in enforcing the employment of qualified, sufficient and careful management; inspection both dependent and independent; and prohibition of all dangerous practices short of the employment of human beings in a mine at all, has now, by the passing of the Workmen's Compensation Act, gone still further in making the employer responsible for injuries sustained or arising from circumstances and conditions which are largely beyond his control, no matter what amount of care, means and expense he bestows. In order to comprehend and estimate the enhanced extent of the owners' liability by this recent Act over their responsibility under the Employers' Liability Act of 1880, it is essential to make a comparison of the provisions of each.

The amount of compensation recoverable for injury under the Employers' Liability Act is not to be more than such sum as may be found to be equivalent to the estimated earnings during the 3 years preceding the injury of a person, in the same grade during those years in the like employment and in the district wherein the workman is employed when the injury happened. In making a claim, the workman must first prove negligence. The employer may claim non-responsibility (1) on the ground that the injury arose from ordinary trade risk, of which the injured party was fully aware, and received better remuneration than the labour would be worth without the risk; and (2) there may be contributory negligence of the injured person proved as a good defence.

A claim under the Workmen's Compensation Act may be made, which cannot be resisted unless the employer can prove that the accident occurred through the direct negligence of the person injured, no relief being afforded if it arose by the direct violation of the law or rules by any other person. Since the passing of the Workmen's Compensation

Act, I have endeavoured to analyse the various causes of accidents at one colliery for a year, and the result of my investigations may be of interest to the members of the Institute, and supplement the information contained in the various Government records, returns and reports which are available. It may also be the means of directing our attention along more definite lines, when we have a clear idea of the causes of so many accidents too trivial to be reported to the inspectors, and, therefore, not included in his statistics, yet which will affect to a considerable extent the amount disbursed in compensation by the mine-owner. At the selected colliery, I have taken for a period of 1 year the number of persons injured underground and at the surface respectively, as well as can be ascertained, and attributable to the causes set forth in the table. Of course it will be understood that between some accidents it is difficult to draw a line, but I hope that the tables will be sufficiently definite to answer the purpose desired. In all, 468 accidents were recorded, resulting in the loss of 5,938 days' work, and the details are recorded in Tables I. and II.

TABLE I.—STATEMENT SHOWING ALL ACCIDENTS FROM JULY 19TH, 1897, TO JULY 18TH, 1898.

Causes of Accidents.	Underground.				Surface.			
	Accidents.		Days Off Work.		Accidents.		Days Off Work.	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
(A.) Not carrying out rules	12	2·564	125	2·104	1	0·214	1	0·017
(B.) Preventable, by more stringent regulations	1	0·214	119	2·004	—	—	—	—
(C.) Arising through lack of proper precautions on the part of the injured person, though not in contravention of rules, viz., error of judgment	49	10·470	1,287	21·675	9	1·923	36	0·606
(D.) Occurring without indication of danger	114	24·358	1,527	25·716	1	0·214	43	0·724
(E.) Attributable to want of care on the part of the injured person	157	33·547	1,681	28·309	10	2·137	100	1·684
(F.) Attributable to want of care on the part of others	5	1·068	15	0·252	3	0·641	4	0·068
(G.) Other accidents, but not defined (generally under D and E)	106	22·650	1,000	16·841	—	—	—	—
Totals ..	444	94·871	5,754	96·901	24	5·129	184	3·099

TABLE II.—SHOWING THE NUMBER OF DAYS OFF WORK THROUGH INJURY TO SEVERAL PARTS OF BODY.

Classification.	A.		B.		C.		D.		E.		F.		Total Days off Work.
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.
Toe	49	0·825	—	—	—	—	22	0·370	2	0·034	—	—	73
Foot	—	—	—	—	57	0·960	243	4·093	261	4·395	—	—	561
Ankle	—	—	—	—	8	0·135	80	1·348	148	2·492	—	—	236
Leg	5	0·084	119	2·004	420	7·074	464	7·815	213	3·587	14	0·236	1,235
Thigh and hip	—	—	—	—	32	0·539	96	1·616	228	3·840	—	—	356
Abdomen	3	0·051	—	—	25	0·421	42	0·707	80	1·347	—	—	150
Back	6	0·101	—	—	112	1·886	122	2·055	316	5·321	—	—	556
Shoulders	—	—	—	—	56	0·944	81	1·364	15	0·252	—	—	152
Arms and wrist	8	0·134	—	—	113	1·903	61	1·027	174	2·930	—	—	356
Hand	—	—	—	—	15	0·252	155	2·610	272	4·580	—	—	442
Thumb	—	—	—	—	13	0·219	78	1·313	120	2·021	—	—	211
Fingers	5	0·084	—	—	150	2·526	204	3·435	393	6·620	—	—	752
Ribs	—	—	—	—	—	—	57	0·960	64	1·078	—	—	121
Side	—	—	—	—	8	0·135	21	0·354	11	0·185	—	—	40
Neck	—	—	—	—	—	—	—	—	—	—	—	—	—
Head	36	0·606	—	—	144	2·425	52	0·876	86	1·450	5	0·084	323
Face	—	—	—	—	4	0·067	15	0·252	24	0·404	—	—	43
Eyes	14	0·236	—	—	166	2·795	77	1·297	74	1·246	—	—	331
Totals	126	2·121	119	2·004	1,323	22·281	*1.870	31·492	*2.481	41·782	19	0·320	5,938

* The number of days off work under class G (1,000) of Table I. have been allocated to class D (300) and E (700) in this table.

It will be observed from the tables that only one accident occurred which could have been prevented by more stringent regulations, whilst about 25 per cent. of the total number of accidents occurred without any indication of extraordinary danger. One-third of the underground accidents and over one-fourth of the surface accidents are distinctly traceable to want of proper care on the part of the injured person, and these injuries chiefly happened to the fingers, followed by the back. The latter percentage is doubtless much augmented by the numbers under the head undefinable, a large number appearing thus, but generally of a trivial character, though including a number of more serious accidents which could not be certainly attributed to carelessness. For compensation calculations, the portion of the body carrying the highest insurance is the leg, on account of the number of accidents and the time required to heal the injury.

Whilst nothing can be done to prevent a man from trapping his fingers by lifting a stone improperly into a tub; from falling down over rails, ropes, etc.; from sticking a pick into himself; from getting squeezed between a tram and the side of the road in his hurry to get out at the termination of a shift; from spraining his back by lifting, etc.; from trapping his hands by running tubs against props; from putting his feet under waggon wheels, and such like injuries, I would endeavour to draw the members' attention to the great advantage in every way derivable from the adoption of simple appliances to obviate risks that may be avoidable.

Much has been done by the improvement and use of coal-getting machinery, high-explosives, safety-lamps, automatic stopping-gear to engines, apparatus to prevent cages from falling in shafts, etc.; but there still remains ample scope for the exercise of ingenuity and resource. Can anything be done to facilitate the drawing of timber in wastes (a fertile source of danger); can we devise a simple and efficient brake for tubs; better attachments for tubs and ropes to trains; indicating signals; self-acting separation-doors; catches on inclines to prevent runaways; a method of breaking-down coal without the necessity of a man being in front; easily set and removable sprags; and innumerable other remedies which daily suggest themselves to those directly engaged in and about a mine?

I am inclined to think that many members could render very valuable service to the Institute by drawing attention to details in the practical working and management of mines if they were not too diffident to do so, perhaps esteeming such details too insignificant to be of use or

interest. I would impress upon all who take that view that industrial machinery in its entirety is made up of small details, and any information thereon is undoubtedly most acceptable, and perhaps of even more practical use than elaborate and highly scientific essays, although they too are indispensable.

The dearth of contributions to the *Transactions* of the Institute is owing, I believe, to disinclination to take the trouble to prepare elaborate papers, and reluctance to give a simple account of some occurrence or contrivance which may be open to criticism. I would appeal to the members not to be deterred by such impressions, assuring them that the Institute will most gladly welcome and appreciate the information, and I hope that many will be induced by these remarks to supplement the records of the Institute with up-to-date practical papers.

Mr. JNO. NEVIN (Mirfield), in moving a vote of thanks to the President for his address, remarked that it was a difficult matter to say anything new in a presidential address, because at least six presidential addresses were delivered each year to the members of the Federated Institutes. The members had listened to a thoroughly practical address, affording hints which he hoped a good many of them might be able to follow.

Mr. H. WALTERS seconded the motion, which was carried.

Mr. H. ST. JOHN DURNFORD (Ackton Hall colliery) asked how many persons were employed at the colliery referred to in the presidential address.

The PRESIDENT, after thanking the members, said that he had purposely left out the number of persons employed, as he thought that comparisons between one place and another were invidious. The figures were published so as to supply information as to the percentage of accidents arising from various causes, how far they might be guarded against, how far they were owing to the injured person's own negligence, the parts of the body which were most liable to injury, and the length of time during which the injured persons were off work. The same percentages would apply to all collieries where like injuries took place, although perhaps not in the same proportions.

DISCUSSION ON MR. W. E. GARFORTH'S "SUGGESTED RULES FOR THE RECOVERY OF COAL-MINES AFTER EXPLOSIONS."*

The PRESIDENT said that the Council had been considering the advisability of establishing stations, with convenient access to collieries, where apparatus could be kept which would be useful and fit for use, and that a number of men should be trained in their use, so that they would be available at any time. A committee had been appointed to draw up a scheme, which, after approval by the Council, would be afterwards submitted for the consideration of the members.

Mr. H. B. NASH (Barnsley) suggested that the committee could compile from the suggested rules put before them by Mr. Garforth some concise rules which could be posted by the side of the General and Special Rules which they were obliged to put up by the Coal-mines Regulation Act, and also at some prominent positions in the mine. The miners, as well as the officials, would then become conversant with the general principles there deduced. There was no doubt that the safety and recovery of the men in the mine after an explosion depended to a great extent upon the miners themselves, as to how they should get out of the mine in case of accident.

Mr. T. B. A. CLARKE (Lidgett colliery) approved of Mr. Nash's suggestion. He was in Austrian Silesia this year, and saw an apparatus which fitted over the head, and was supplied with oxygen; and these appliances were hung up ready for use at nearly every colliery in that district, so that if men were imprisoned in an irrespirable atmosphere, other men could enter with this apparatus, carrying spare ones to the imprisoned men, and bring them out in safety. This apparatus had been tried abroad with considerable success. In the case of an explosion in Prussia, 16 lives were saved by the use of this apparatus; and the Prussian government gave a grant of money to the men who ventured in with it and rescued these lives. At such times, everything turned on having efficient apparatus ready (not at every colliery, though it would be better so) and easily obtainable, in the case of a number of men being imprisoned in a noxious atmosphere.

* *Trans. Inst. M.E.*, vol. xiv., page 495; and vol. xv., pages 134, 210, 249, 261 and 268.

Mr. H. ST. JOHN DURNFORD (Ackton Hall colliery) stated that the Walcher pneumatophore had been described in the *Transactions*,* and some of the members had used them at their collieries, two being ready for use at Ackton Hall colliery. The apparatus had been very greatly improved, and now consisted of a sort of diving-bell, which was put on, and was more comfortable than that in which the nose was closed by a pair of pincers.

Mr. C. C. ELLISON said that in the improved apparatus, a mask, with a glass to look through, fitted the face, and this was much better than the mouthpiece and nippers which were placed over the nose. He saw the men working with this apparatus, and he believed that they could do a very fair amount of work for something like 1 or 1½ hours. The improved apparatus was fitted with two cylinders of oxygen, so that when one cylinder was emptied, the user knew that he had been there a little more than half the time that he should be, and he could then consider how much longer he should remain.

Mr. H. E GREGORY said that, in many cases, if it had been brought to the mind of the persons in the mine at the time of an explosion or fire that they could escape through the return airways, many lives might have been saved. An underground fire occured 27 years ago at a colliery with which he was intimately connected, and it was proved in the enquiry which took place, that, had the men gone forward in the return airway, their lives would have been saved. Recently, at the Whitwick colliery, a number of men's lives would have been saved had they gone forward in the return airway. He approved of Mr. Nash's suggestion that rules should be compiled, giving men guidance in cases of explosion and fire, in matters of which they were, to a great extent, entirely ignorant.

Mr. J. R. R. WILSON said that Mr. Garforth's paper was full of rules, and covered all the suggestions which could be mentioned as to safety-appliances, and the means to be adopted for recovering men from the mine. Excerpts should be made from those rules, and placed upon the pit-heaps.

The PRESIDENT said that the various suggestions would be considered by the Council. There was great difficulty in getting workmen to do anything tending to their own safety or anybody else's, except what they were accustomed to do by their training. For instance, at Denaby and

* *Trans. Inst. M.E.*, vol. xiv., page 575.

Cadeby collieries, where 4,000 people were employed, ambulance classes had been carried on for many years, and it was considered a very good attendance if they could get 25 to a class. There was plenty of legislation throwing responsibility upon owners, managers and officials, but nothing had been done requiring the men to pass an examination or even to know anything. He thought that Parliament should make workmen pass an examination (as they did at school in reading, writing and arithmetic), so as to ascertain whether they knew what a collier should do in a mine. The manager might post up the rules, but the colliers would not read them.

DISCUSSION ON MR. W. BAYLEY MARSHALL'S PAPER ON "ROLLER-BEARINGS."*

Mr. H. B. Nash said that from the specimens exhibited in London, and the possibility of their reducing friction, there was not the slightest doubt that their application to fans was particularly desirable—if they could be supplied at a reasonable cost.

Mr. J. E. Chambers (Tinsley colliery) said that, at a Durham colliery, a large fan had been started with roller-bearings applied to it.

Mr. T. B. A. Clarke (Lidgett colliery) said that roller-bearings would not strengthen the shaft, the benefit to be derived was economy in the use of oil and 1 or 2 horsepower in friction. In his experience, roller-bearings, in good condition, worked very well, but they were apt to stick and give trouble.

Mr. H. B. Nash said that roller-bearings had been applied to the tramcars at Blackpool for over 3 years, and they effected a saving of 30 per cent. upon the cost of horsepower in dragging the cars as compared with the bearings in ordinary use.

The President said that a year or two ago he had tried a pit-tub fitted with roller-bearings, but it was not a success, as the rollers and axles were soon destroyed by dirt. The consumption of oil on an ordinary bearing was considerable, owing to dirty roads and to dust, and he was desirous of trying anything that would reduce it. There might be a saving by the increased duty of the engine and a small reduction in the consumption of coal, in the case of a fan and engine, by substituting roller-bearings for ordinary bearings, but these conditions were favourable to ordinary lubrication. He did not think that there could be much economy, after his experience of the pit-tub.

* *Trans. Inst. M.E.*, vol. xv., page 302.

DISCUSSION ON DR. C. KROSEBERG'S PAPER ON "THE OTTO COKE-OVEN." *

Mr. C. C. Ellison said that he had recently seen the latest form of Otto oven, fitted with the Bunsen burner working underneath, and they seemed to be working extremely well. It was thought, when the arrangement of Bunsen burners was invented, that it would be too hot for a man to go under the ovens to tend the burners, but this was not so in practice. The gas could be admitted almost as easily as they could turn on or off an ordinary burner, and the Otto coke-oven was certainly a success.

Mr. H. B. Nash enquired what was the saving as compared with the old system of working Otto coke-ovens?

Mr. C. C. Ellison replied that the new coke-ovens did not require as much gas as the old ones, there was no waste, and the heat-regulation was almost perfect.

Dr. C. Kroseberg wrote that, although the Otto-Hoffmann coke-oven actually gave better results than other competing systems, it still had some defects, such as the needle-flame at the gas entrance, which is close to the oven walls, and the variations of temperature caused by changes in the gas-flow. It is, especially, the uniformity with which the latest type of Otto coke-oven is heated, and the regularity with which it works, that mark its superiority over the Otto-Hoffman coke-oven.

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* *Trans. Inst. M.E.*, vol. xv., page 402.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN THE STEPHENSON MEMORIAL HALL, CHESTERFIELD, AUGUST 27TH, 1898.

MR. G. E. COKE, VICE-PRESIDENT, IN THE CHAIR.

The SECRETARY announced the election of the following gentlemen:—

MEMBERS—

Mr. ALBERT FREDERIC ALSOP, Mining Engineer, Ivy Grove, Ripley, Derby.
Mr. CLAUDE CRESWICK, Mining Engineer, B.C. Syndicate, Rossland, British Columbia, *via* New York and Spokane.
Mr. JOHN HAY, Colliery Manager, Ibstock Colliery, Leicester.
Mr. GEORGE HEPBURN, Mine Manager, Mount Edgerton, Victoria, Western Australia.
Mr. JOHN ROSS, Assayer and Mining Engineer, 9, William's Buildings, P.O. Box 242, Buluwayo.
Mr. THOMAS LEVI SOAR, Underground Manager, Kiveton Park Colliery, near Sheffield.

ASSOCIATE—

Mr. ALFRED NAYLOR, Under Manager, Cotes Park Colliery, near Alfreton.

STUDENT—

Mr. FREDERICK POVEY HARPER, Mining Student, Blackwell Collieries, near Alfreton.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS.

Mr. G. J. BINNS.
Mr. G. E. COKE.
Mr. M. DEACON.
Mr. W. D. HOLFORD.
Mr. W. F. HOWARD (*ex-officio*).
Mr. J. JACKSON.
Mr. H. LEWIS.
Mr. J. A. LONGDEN.
Mr. M. H. MILLS.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL.

The following is the usual comparative summary of the number of members and the state of the finances in the past three annual statements, viz.:—

	1¼ Years. 1895-96.	Year. 1896-97.	Year. 1897-98.
Honorary Members ...	14	14	14
Life Members	9	9	9
Members	214	221	235
Associate Members ...	2	2	4
Associates	76	70	66
Students	34	37	32
	349	353	360
	£ s. d.	£ s. d.	£ s. d.
Cash Receipts	683 13 3	504 8 1	458 3 5
Cash Payments ...	537 13 10	506 6 7	515 8 9
Bank Balance	87 9 9	85 11 3	28 5 11
Invested Fund	533 6 8	533 6 8	533 6 8
	£620 16 5	£618 17 11	£561 12 7
Arrears considered recoverable at end of	1895-96. £52 16 0	1896-97. £51 2 0	1897-98. £72 13 6

Twenty-four new Members (including 2 Associates and 11 Students transferred), 2 Associate Members, 4 Associates and 7 Students, have been elected during the year—total 37 (as against 42 last year).

The total retirements from all causes are 28 (as against 38 last year), viz.:—8 Members, 8 Associates and 12 Students.

There has been a net increase of 14 Members and 2 Associate Members; and a net decrease of 4 Associates and 5 Students. Total net increase, 7.

Three Members and 1 Associate have died during the past year, and are further referred to in Memoirs.

The total number on the roll of the Institution, as for the year commenced August 1st, 1898, was 360.

The number of Members and Associate Members continuing for the ensuing year, viz.:—239, is 16 more than in the previous year, and the most satisfactory feature of the figures as a whole.

Compared with 1896-97, the income of 1897-98 was £46 4s. 8d. less; and the expenditure was £9 2s. 2d. greater. The arrears considered recoverable were £21 2s. 6d. greater.

The invested fund continues untouched. The bank balance was reduced £57 5s. 4d. during the year.

An increase of contribution to The Institution of Mining Engineers at the rate of 2s. per Member absorbed £29 16s. Enlargement of bookcase and removal of books, etc., in the Stephenson Memorial Hall, cost £17 10s.

The reduction of the bank balance calls for attention and remedy.

The existing scale of subscriptions has been in operation about

twenty years, *i.e.*, from 1877, coupled at a later date with the admission of Associates at a specially low rate. During that period, and notably in the nine years last past, through the Federation, the publications and other advantages thence arising have become more than six times greater. With such increase, some larger working cost was unavoidable. It has already compelled two other of the Institutes, viz., the North Staffordshire Institute of Mining and Mechanical Engineers and the Mining Institute of Scotland to raise their rates of subscription subsequently to the Federation, and the Council of the Chesterfield Institution advise that a similar course should now be adopted as the only sound method of dealing with the matter.

The new Council, now on the point of election, are the proper persons to take up and submit the question to the general body of members.

The annual meeting of The Federated Institution of Mining Engineers was held in September at Edinburgh. The other meetings were held in February, at Newcastle-on-Tyne, and in June, in London. The word "Federated" is now expunged, and "The Institution of Mining Engineers" is henceforth the correct title.

Local meetings were held in Chesterfield on August 28th; in Nottingham, on December 11th; and in Derby, on April 2nd. In addition, two joint meetings with the Midland Institute of Mining, Civil and Mechanical Engineers took place in Sheffield on October 26th and February 5th.

The complete list of papers published in the *Transactions* of The Institution of Mining Engineers since the Council's last report includes the following contributions from the members of this Institution:—

"Explosions in Air-compressors and Receivers." By Mr. T. G. Lees.
"Electric Blasting, Part I." By Mr. Wm. Maurice.
"The Walker Hollow Needle for Firing High Explosives." By Mr. J. Mein.
"Memoir of the late Wm. Armstrong." By his son, Mr. W. Armstrong.
"Memoir of the late Richard J. Strick."
"Memoir of the late Henry Amos Knighton."
"Internal Corrosion of Wire Ropes." By Mr. Thos. G. Lees.
"Report on an Explosives Testing-station." By a Joint Committee.
"Memorandum on the Proposed Station for Testing Explosives at Woolwich." By a Joint Committee.
"Electric Blasting, Part II." By Mr. Wm. Maurice.
"Electric Blasting, Part III." By Mr. Wm. Maurice.
"Photographs of Flashes of Electric Detonators." By Mr. L. W. de Grave.
"Wagner Portable Pneumatic Safety-stopping for Mining Purposes." By Mr. Richard Cremer.
Excursion.—Shipley Collieries.

The Annual Meeting of The Institution of Mining Engineers is fixed to be held at Birmingham, on September 13th, 14th and 15th, 1898.

ABSTRACT OF ACCOUNTS,

	INCOME.				£	s.	d.	£	s.	d.
186	Members at £1 11s. 6d.				292	19	0			
4	Members Transferred from Students				6	6	0			
2	Associate Members				3	3	0			
73	Associates and Students				73	0	0			
9	New Members and Entrance Fees				23	12	6			
1	Former Member re-entered				1	11	6			
1	Member paid Subscription only, having previously paid entrance as arrear				1	11	6			
	Six Entrance Fees from Students				3	3	0			
2	New Associate Members and Entrance Fees				5	5	0			
10	New Associates and Students				10	0	0			
								420	11	6
288										
	Two Members paid in advance, 1898-99				3	3	0			
	One Associate paid in advance, 1898-99				1	0	0			
								4	3	0
								424	14	6
	Arrear Subscriptions received, in List				11	11	0			
	Do. do. and Entrance Fee not in List ...				3	12	6			
								15	3	6
	Excerpts sold							0	2	0
	Midland Railway Company's Debenture Interest ...							15	9	4
	Bank Interest							2	14	1
	Total Receipts ...							458	3	5
	Balance from last year							85	11	3
	Unpaid Arrears as per Subscriptions Account ...				68	19	0			
	Do. 1896-97 Account...	£28	6	6						
	Do. 1895-96 do.	11	4	6						
					39	11	0			
					108	10	0			
	Deduct Irrecoverable				35	16	6			
								72	13	6
								£616	8	2

Certificate of £533 6s. 8d. Midland Railway Company's 3 per Cent. Debenture Stock, and Policy of Assurance with Alliance Co. for £500, deposited in Bank.

YEAR ENDING JULY 31ST, 1898.

EXPENDITURE.	£ s. d.	£ s. d.
The Institution of Mining Engineers upon copies of *Transactions*, supplied at 19s. per Member:—		
Balance of Calls, 1897-98 (Vols. XIV. and XV.) ...	283 2 0	
Balance of Calls, 1896-97 (Vols. XII. and XIII.) ...	11 18 0	
Transactions supplied on payment of arrears ...	3 0 0	
		298 0 0
Excerpts, Exchanges, etc.	12 12 7	
Reducing Plates...	5 10 0	
		18 2 7
		316 2 7
Printing and Stationery, A. Reid & Co., Ld.	22 16 2	
Do. do., Bemrose & Sons, Ld.	13 4 11	
Do. do., F. H. Edmunds	0 15 6	
		36 16 7
Auditors		3 3 0
Reporting Proceedings		9 9 6
Fire Insurance		0 14 6
Postages, Parcels and Telegrams		13 8 8
Travelling and Incidental Expenses		16 0 6
Fees at Meetings, Requisites and Services		0 9 11
Secretary's Salary, Assistance and Use of Office		100 0 0
Joint Meeting at Sheffield—Room		1 1 0
Chas. Rollinson, Addition to Bookcase and Removing Books, etc.		17 10 0
Bankers' Commission		0 12 6
Total Expenditure ...		515 8 9
Arrear Subscriptions		72 13 6
Balance as per contra		28 5 11
		£616 8 2

August 11th, 1898,

Examined and found correct,

JOHN HALL,
JOHNSON PEARSON, } AUDITORS.

DR. THE TREASURER IN ACCOUNT

		£	s.	d.	£	s.	d.
229	Members, as per List, 1897-98, of whom						
8	are Old Life Members						
221	Members at £1 11s. 6d.	348	1	6			
	Less 9 paid in advance last year and previously ...	14	3	6			
					333	18	0
	Two Members paid in advance, 1898-99				3	3	0
4	Four Students paid difference as Members				2	6	0
	Four Students Transferred, Entrance Fees				2	2	0
	Two former Students, Entrance Fees				1	1	0
2	Associate Members, as per List				3	3	0
108	Associates and Students, as per List, of whom						
1	Student is a Life Member						
107		107	0	0			
	Less 2 paid in advance last year and previously ...	2	0	0			
					105	0	0
	One Associate paid in advance, 1898-99				1	0	0
9	New Members and Entrance Fees	23	12	6			
1	Member re-entered	1	11	6			
1	Member paid Subscription only, having previously paid Entrance Fee as arrear	1	11	6			
2	New Associate Members and Entrance Fees	5	5	0			
10	New Associates and Students	10	0	0			
					42	0	6
23							
366					493	13	6
	Arrears per last Balance Sheet	51	2	0			
	Do. not in last Balance Sheet	3	12	6			
		54	14	6			
	Deduct Irrecoverable, not included in 1898-99... ...	35	16	6			
					18	18	0
					£512	11	6

WITH SUBSCRIPTIONS, 1897-98. Cr.

		Unpaid. £ s. d.	Paid. £ s. d.
186	Members at £1 11s. 6d.		292 19 0
	Eight Old Life Members		
9	Paid in advance last year and previously		
26	Unpaid	40 19 0	
221			
	Two Members paid in advance, 1898-99		3 3 0
4	Four Members transferred from Students		2 6 0
	Four Students transferred, Entrance Fees		2 2 0
	Two former Students, Entrance Fees		1 1 0
2	Associate Members, paid		3 3 0
77	Associates and Students, paid		77 0 0
2	Paid last year in advance		
28	Unpaid	28 0 0	
107			
	One Associate paid in advance, 1898-99		1 0 0
9	New Members and Entrance Fees		23 12 6
1	Member re-entered		1 11 6
1	Member paid Subscription only, having previously paid Entrance Fee as arrear		1 11 6
2	New Associate Members and Entrance Fees		5 5 0
10	New Associates and Students		10 0 0
23			
366			
		68 19 0	424 14 6
	Arrears as per last Balance Sheet	39 11 0	11 11 0
	Do. not in last year's list		3 12 6
		108 10 0	439 18 0
	Irrecoverable	35 16 6	72 13 6
			£512 11 6

August 11th, 1898.—Examined and found correct,

JOHN HALL,
JOHNSON PEARSON, } AUDITORS.

The CHAIRMAN moved the adoption of the Report.

Mr. T. G. LEES (Newstead) seconded this motion, and the Report was unanimously adopted.

ELECTION OF OFFICERS—1898-99.

The scrutineers (Messrs. G. Hall and C. J. Oliver), who received the thanks of the meeting for their services, reported the result of the ballot as follows :—

PRESIDENT.

Mr. W. D. HOLFORD.

VICE-PRESIDENTS.

Mr. G. E. COKE.	Mr. C. R. MORGAN.
Mr. M. DEACON.	Mr. C. S. SMITH.
Mr. H. R. HEWITT.	Mr. H. WALTERS.

COUNCILLORS.

Mr. G. S. BRAGGE.	Mr. W. B. M. JACKSON.
Mr. P. M. CHESTER.	Mr. J. H. W. LAVERICK.
Mr. A. S. DOUGLAS.	Mr. G. A. LEWIS.
Mr. W. H. HEPPLEWHITE.	Mr. E. LINDLEY.
Mr. C. R. HEWITT.	Mr. J. T. TODD.
Mr. J. P. HOUFTON.	Mr. W. WILDE.

PAST-PRESIDENTS (*ex-officio*).

Mr. G. LEWIS.	Mr. A. BARNES.
Mr. J. JACKSON.	Mr. W. SPENCER.
Mr. J. A. LONGDEN.	Mr. E. BAINBRIDGE.
Mr. H. LEWIS.	Mr. M. H. MILLS.

VICE-PRESIDENTS OF PREVIOUS YEAR (*ex-officio*).

Mr. G. J. BINNS.	Mr. T. A. SOUTHERN.

TREASURER.

Mr. E. EASTWOOD.

SECRETARY.

Mr. W. F. HOWARD.

Mr. J. B. SMITH moved a vote of thanks to the retiring President, Mr. M. H. Mills, who had filled the office for two years in a very able manner.

Mr. M. DEACON seconded the proposal, and it was cordially adopted.

The PRESIDENT then took the chair, and delivered the following address :—

PRESIDENTIAL ADDRESS.

By W. D. HOLFORD.

Year by year it becomes more difficult to fix upon some branch of the subject of mining engineering, suitable for a presidential address, as those who have preceded me in this position have, more or less, spoken on the principal subjects connected with the profession. I am fully conscious of the honour you confer upon me in electing me, unanimously, to the position of President for the coming year, and it is a pleasure to me to know that I shall be very ably assisted during that period by the Council, Members and Secretary of the Institute. I should not have been disappointed if your choice for the presidency had fallen upon a younger man who could have been expected to devote greater energy than I can to the various duties connected with the office; but I think that I understand your kindness in this respect has arisen from your knowledge that I am one of the earliest, and, I regret to say, one of the oldest members of the Institute. In the natural order of things, lapse of years has told upon us, so that many of those who joined at the same time as I did have passed away.

You are all aware that there are many practical questions still before us to solve. Of these, however, I wish to-day to confine your attention mainly to those which more particularly affect colliery management. Let me, in the meantime, ask your forbearance if I do not quite succeed in stating some of these questions so clearly as you could wish.

It has often been said that the prosperity of this country depends largely on its powers to maintain an abundant supply of cheap coal. If this be so, those men who succeed the best in economizing the working of our mines are performing a national service.

Waste of Coal.—I will ask your attention then, first, to the important question of waste of coal. Waste of coal at the colliery itself may be charged against three classes of persons. First, the mineral owner, who may contribute to this waste by insisting on excessive minimum rents and wayleaves, and leaving of pillars and barriers of coal for the protection of his estate.

The CHAIRMAN moved the adoption of the Report., it is evident that

Mr. T. G. LEES (Newstead) seconded this r- from the commence-
was unanimously adopted. .come productive, capital
.ral owner. Very little con-
.h prepayments absorb capital

ELECTION OF OFF' .elopment of the mine. It would

The scrutineers (Messrs. G. F .fficulty to you if I did not venture
the thanks of the meeting for In my opinion, the time allowed for
ballot as follows :— of minimum rents has, hitherto, been
much longer period ought to elapse before
be paid. I say this in the interest of the
that of the colliery owner. When the full
Mr. G. E. COKE. too early a date, the colliery owner is often
Mr. M. DEACO' development of his colliery too quickly, and in such
Mr. H. R. F excessive number of headings with narrow pillars.
Mr. G. become crushed, and the coal, if not rendered value-
Mr. J difficult to utilize.
Mr
M

Wayleaves.—In my opinion there are only two conditions under which wayleave rents are justifiable :—(*a*) Where an estate is so geographically situated, as to command the market outlets (railway, canal or road), and then only when the estate is of itself large enough to ensure reasonable interest on, and a return of, the capital expended in its development; (*b*) when the underground roads under one estate are used as occupation-roads only, for the purpose of conveying coal from an adjoining estate, after its own coal has been got.

Pillars.—Now let us consider the question of pillars. These are often left for the protection of buildings, which are of little more actual value than the coal supporting them. In many such cases, however, it might be found advisable to get the whole of the coal, and take the risk of any damage which might ensue. As the mineral owner, under these circumstances, would receive the whole of his royalty, probably the members will agree with me in thinking that he ought to bear a fair proportion of any loss sustained by damage of the property above.

Barriers.—The barriers left for the protection of boundaries are another important point to consider. These barriers are often necessary to prevent water from one estate flooding another, or as a security against old workings. But as it has hitherto been found impossible to fix a rule by which the precise width of these barriers should be determined, we are still uncertain as to what ought to be left to ensure safety. Thus it often happens that a wider barrier is left than is really necessary,

so much coal is lost. One method of avoiding loss of coal in ·s is to amalgamate neighbouring estates. Under such circum- the whole of a coal-basin, or a large proportion of its area, dvantageously worked by fewer shafts, and probably by one ion. This system of joint pumping, as you are aware, is n in Staffordshire.

ond class of persons to whom I referred consists of the y owners who, at the outset, at the beginning of a colliery, do not erect the best kinds of machinery, such as boilers, engines and pumps. These men are often most wasteful in their mode of producing power, as if the coal they burnt at the pit cost them nothing ; also many colliery owners fail to adopt the best appliances for utilizing the whole of each coal-seam, and taking it to market in its best form. Perhaps it may not be too much to say that in these various kinds of inefficiency there is, in many cases, a loss of as much as 20 per cent.

Workmen.—We will now deal with the third class, the miners. We all know that conscientious labour must be a main factor in all success. When the miner can be brought to see that his interest and that of his employer are absolutely identical, we shall have better and more economical work. When this happy time arrives we shall see that the miner's share of responsibility for waste will be considerably reduced, because he will undercut and load the coal in the pit with greater care than hitherto, and thus considerably reduce the quantity of coal which is now being thrown into the gob.

Modern Plans.—In order to maintain a strict watch over waste, it is desirable to utilize every opportunity of ascertaining the difference between the quantity of coal brought to the surface and that which has been got below; it is obvious that this difference can only be ascertained by means of a frequent survey and plan, and these plans should show the relative position of both surface and underground works. Considerable care and skill are required where the mines are steep, and the gradients variable, to produce accurate underground measurements for this purpose. A colliery plan should show, in varied colouring, every bit of coal worked within certain periods, and the thickness of that part of the seam which ought to go to bank should be measured at least monthly at each working-face. By this means, it will be possible to compare the actual quantity of coal which has been mined with the quantity brought to bank—the difference between the two being the loss.

The usual practice of comparing these quantities half-yearly or

yearly, based on measurements taken for royalty purposes only, is not sufficiently accurate as a check on waste. Let us assume that 1 acre of coal, 1 foot thick, contains on an average 1,550 tons—of this gross quantity it is probable that not more than 1,200 or 1,250 tons finds its way to the surface; indeed, I have heard it stated that 1,000 tons is a sufficiently high estimate. You are aware that in Derbyshire, Yorkshire, and some other counties it is customary to leave for a time unmeasured and unpaid for coal got from headings or narrow-work; but if a strict watch is to be kept over every department to prevent waste, these must be taken into account, whether the royalty is paid at the time or not. Assuming that the figures which I have mentioned are correct, the difference is so great as to call for serious investigation.

Old Plan.—I have brought with me to-day an old plan. This may be interesting to you as showing how a colliery was worked during the period between 1808 and 1847. It seems to me that it is a specimen of really good work for that time. On close examination, the members will see that portions only of the surface are delineated, and I am inclined to think that, as it was the practice to set out on the surface, the position of the main roads, and put down pegs to locate brows, etc., portions of the surface and boundaries were surveyed at the same time. This was sufficient for the purpose of ascertaining the point at which the royalty, or "quarterage," as it was called. became payable to the various owners. The "quarterage" in the mine, to which I am drawing your attention, was based on the proportion of one-sixth of the value of the coal when sold. Many of you may think that these old methods of setting out roads on the surface are somewhat crude, but perhaps on this system there would be less risk of error than on our modern one, where we depend entirely on the plotting of surveys on a variable paper surface.

Then and Now.—As to the working of this pit, near to which I lived when a boy, many a piece of picturesque machinery was in use—such as can nowhere be seen now. There was in sight, a large water-wheel which operated three huge baulks of timber attached to the pumping-rods. As the coal dipped at an angle of 28 or 30 degrees (rather more than 1 in 2) and the greater part lay on the deep of the shaft, underground pumping- and hauling-machinery was imperative. The members will notice that the plan shows that the hauling up the brows was done in short stages, and that the power was produced by vacuum engines.

The old colliery to which I refer was closed in the year 1847, but it is now being re-opened and worked further on the deep by means of modern machinery, chiefly electric. A full description of this machinery

may be found in the *Transactions* of our Institution.* I need hardly say that great advances have been made in the mode of working, and in the machinery employed at this colliery; one winding-shaft is doing the work of the former three, and the output has been largely increased—but I venture to think that the profits are not as they were in the old days.

We have to remember for the future that all monopolies in trade and commerce are fast disappearing—that to rely on old methods and old ways—while other nations, with an increasingly technical education, are treading on our heels—will be to put ourselves in a most risky position. There are larger and larger supplies of coal being discovered in other countries, and the new three and four-cylinder engines in steamers which enable the Californian grain-producer to compete successfully with our home-grown cereals, are equally powerful for the distribution of all other articles of trade, from every quarter of the globe. The coal of Japan and China may, in the future, supply the needs of the Far East, while at home, Belgian, Westphalian, and other pits may compete with ours. Strikes will be more and more productive of permanent loss, because all countries are being brought nearer to each other, and their wealth, both as regards labour and material, is passing through a process of equalization. It remains for the labour-leaders to remember that there will only be a certain margin to divide, and, that if the coal-industry is to be prosperous in Great Britain, this margin will have to be reasonably shared between the labourer and capitalist—in fact any permanent arrangement must of necessity be on the basis of a living profit, as well as a living wage.

Mr. M. Deacon moved, and Mr. G. J. Binns seconded, a vote of thanks to the President for his address.

The resolution was carried with acclamation and duly acknowledged.

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* *Trans. Inst. M.E.*, vol. xiii., page 127.

DISCUSSION UPON MR. W. E. GARFORTH'S "SUGGESTED RULES FOR THE RECOVERY OF COAL-MINES AFTER EXPLOSIONS." *

Mr. A. H. STOKES (H.M. Inspector of Mines) said that the members must take Mr. Garforth's paper as a whole, and not in strict detail, because there were no two explosions alike, and, consequently, very much must be left to the person in charge to deal with in an exceptional way after an explosion. He approved of rule 15 pointing out that men should be accustomed to travel periodically certain roads other than those leading direct to their work; and also rule 16 for the placing of direction-boards showing the way either to the upcast or the downcast shaft. Rule 17 was one of the best, viz., to have all lamp-rooms at the surface. He was of opinion that every colliery official, from the highest to the lowest, should be an ambulance-man, and that there should be ambulance-corps in connexion with every colliery (rule 18). As to rule 61, proposing the provision of leather gloves to be used in the handling of dead bodies, he thought that indiarubber gloves were in every respect better than leather, owing to the absence in the former of stitches and seams. He was of opinion that, on the whole, Mr. Garforth's paper comprised a good code of rules, well worth studying by every member of the Institution.

Mr. M. DEACON said that there was one point on which he expected that Mr. Stokes would have made some remark, viz., the collective adoption by colliery-owners in a district of life-saving apparatus, which would enable persons to enter into noxious gases. He thought it was a matter of great importance for the purposes of exploration either that some such apparatus should be kept by colliery-owners, or that some central-station should be established in which apparatus might be deposited at the joint cost of neighbouring colliery-owners and for their joint use. He had himself given a good deal of thought to this matter, and failing to induce other colliery-owners to enter into the scheme he had adopted such an apparatus himself. It was kept at one of the collieries; and there were written instructions that if it were required at any of the other collieries it was to be telephoned for, and it would be sent at once, together with men accustomed to use it.

Mr. J. B. SMITH said that some years ago he purchased a Fleuss apparatus. He tried it and found it hot, and, he was bound to say,

* *Trans. Inst. M.E.*, vol xiv., page 495; vol. xv., pages 134, 210, 249, 261 and 268; and vol. xvi., page 99.

uncomfortable. Some years afterwards, he had the box containing the Fleuss apparatus opened; and he found that it was mouldy and of no further use, and that like extincteur-engines, unless such apparatus was kept clean and used periodically, it was only a trap. One of the chief requisites after an explosion was discipline. There ought to be with each exploring party a chief and an under-chief, and the chief ought to go in front and the under-chief behind, prepared to take command in the event of anything happening to the chief. Rescue apparatus was not much good unless there was stringent discipline.

Mr. H. R. Hewitt said Mr. Garforth stated in his paper that prior to 1860 the number of lives lost per explosion was 2·98, and since that time it had been 6·25 per explosion.* That statement seemed to cast a stigma on mining engineers of the present day, and he thought that if Mr. Garforth would give the number of tons raised per life lost per explosion, the figures would come out more favourably than the paper at present showed. The rules ought to be well known by everyone connected with colliery management. There was one, however, which he considered unnecessary (rule 14), referring to the exhibiting of a plan of the workings at the pit-top. This rule, he thought, would have been better placed amongst those to be carried out after the explosion occurred, then some useful purpose would be served, and the exhibiting of a plan of the workings would be useful to the explorers in charge of the shifts, who would usually be neighbouring colliery-managers and the higher officials of the mine generally.

Mr. A. H. Stokes said that he was not sure in his own mind as to the value of a central station in the matter of life-saving. If an explosion occurred and they had to wait before rescuing anybody until they had sent to a central station for the apparatus, it would in some cases be a fatal delay and a cruel waste of time. For the saving of life, he did not see where the great advantage came in, but for re-opening a mine after an explosion such appliances would be of great value. If the atmosphere after an explosion was such that a man who had fallen could live in it, it was such as would admit of a rescue party going in carefully and fetching the man out, without waiting to be encumbered with a heap of apparatus. One man was of no use to carry another out, especially if the roof were low—it would require three or four—but if the atmosphere was so bad that they could not penetrate it without the apparatus, then how could the fallen workman live in the atmosphere while the apparatus was

* *Trans. Inst. M.E.*, vol. xiv., page 497.

being obtained from the central station? For the purpose of exploring a mine, or recovering dead bodies, the putting in of dams, the erection of bratticing, or the restoration of the ventilation, he could quite see that such apparatus might be extremely useful, as it would allow explorers to enter noxious gases in advance of the ventilation.

Mr. G. J. BINNS said that he had made the same suggestion as Mr. Deacon, and it appeared in the *Transactions*.* He hardly followed Mr. Stokes' reasoning, because it seemed to him to lead to the result that, except for the purpose of saving property, these various appliances—which perhaps Mr. Deacon might mention in detail—were of no value at all. He did not think that the central station would be much more distant than the colliery-offices. They could not place the apparatus in the mine, and if it were on the surface it would not be within 1 hour or ½ hour's distance of the end of the working-faces. He had always thought that the idea of a central station might be carried out, and he might say that he hoped it would.

Mr. G. E. COKE said that in his opinion Mr. Garforth's paper was a most valuable one, not only on account of its merits, but because it directed attention to the chance of accidents occurring in mines. At many collieries, the last thing which appeared to be borne in mind was the chance of an accident of any sort occurring. A ship was something like a colliery in the liability to sudden accidents, but provision was always made for all likely contingencies, not only by having apparatus ready, but by having men drilled and prepared to take their proper places. He could not help thinking that a great many of Mr. Garforth's suggestions would cause colliery managers to think—with, he hoped, the result of providing some efficient substitute when the ordinary machinery of the colliery was deranged.

The PRESIDENT was afraid that direction-boards in the pit would either be broken or lost, and suggested that white arrows or pointers should be painted on the walls, especially at junctions. Fortunately, colliery accidents, particularly explosions, were not so numerous as they used to be. He remembered, as a boy, at the colliery to which he had referred in his address, that it was a very common occurrence for one or two men to be brought out of the pit, sometimes burnt very severely. There never was any great explosion, but small ones were constantly occurring.

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* *Trans. Inst. M.E.*, vol. xv., page 210.

DISCUSSION UPON MR. T. G. LEES' PAPER ON THE "INTERNAL CORROSION OF WIRE ROPES."*

Mr. M. Deacon said that he used galvanized ropes at one of the pits under his charge and got better results than from the non-galvanized ropes previously used and which had not lasted well owing to corrosion. He found that there was an advantage of about 12 per cent. in the weight drawn per rope. The use of galvanized ropes for haulage in wet mines had been very satisfactory.

Mr. J. B. Smith concurred with Mr. Deacon's statement. Of late years, black-lead had been used frequently for lubricating the inside of wire ropes. Sometimes the core was greased, and as the grease sometimes contained fatty acids, it reacted on the black-lead, setting up electric action, and pitted and corroded the steel. There was no trace of rust in the rope, and he believed that the pitting was often due to the fact that the acids of the grease had not been sufficiently neutralized.

Mr. A. H. Stokes said that a single wire from a new rope would stand about 30 torsion-twists. In the case of a rope tested by Mr. Lees that had been in use for 2½ years, the wire broke in the torsion-test at 10 or 11 revolutions, although its tension-strength was equal to that of a new wire.† The steel wire was drawn at a certain temperature, and then passed through a bath of molten zinc—this operation was a kind of annealing, and altered the temper of the steel. Evidently there was deterioration, because according to Mr. Lees' experiments‡ in non-galvanized wire the average torsion was 27 twists, and the breaking-strain 2,215 lbs.; whereas in the wire when galvanized the torsion was only 25 and the breaking-strain 2,178 lbs. For haulage-ropes in damp or wet roads, he agreed that galvanized wire was the better of the two. He handed round two bunches of galvanized wires, upon which he had made experiments. Those tied with green tape had been subjected to alternate immersions—2 days in water and 1 day out. They were immersed in water for 158 days, and exposed to the atmosphere for 79 days. The water was impregnated with peroxide of iron, and the members would see the effect. With regard to those tied with red tape, the immersion was intermittent—68 days of immersion, and 62 days of

* *Trans. Inst. M.E.*, vol. xiv., page 400, and vol. xv., page 288.

† *Ibid.*, vol. xiv., page 404. ‡ *Ibid.*, page 405.

exposure. It appeared to him that in the case of a wire which was quiescent in certain water, the zinc remained coated upon the wire and probably protected it, for in one sample of wire there was nothing but a film or layer of peroxide of iron, and the galvanizing remained underneath it. In a salt water, very similar to the Nottinghamshire water, there was no layer, but it seemed to have so changed the zinc that when the wire was bent the zinc came off in small pieces, allowing the water to pass through and set up internal corrosion. The only effectual remedy against corrosion was by cutting and re-capping the rope, but that did not help much with regard to the full length of the rope. He continued of opinion that after 2 or 2½ years' work a winding-rope should in the interests of safety be taken off.

Mr. C. J. OLIVER suggested that it was possible to examine the inside of a rope by means of "spritchels."

Mr. G. E. COKE said that Mr. Lees had not only given the members the results of his experience, but had suggested a remedy which had led to a useful discussion. He himself had experience of a hemp rope breaking the first time that it was used, owing to internal decay, although it had been kept in a dry place.

Mr. G. J. BINNS said that Mr. Oliver's remark reminded him that he once had a haulage-rope 4,200 feet long re-cored from end to end, the greater part by his own workmen, after they had been properly instructed.

Mr. T. G. LEES said he did not wish to suggest that galvanizing was the only remedy for internal corrosion. If galvanized ropes were adopted a certain amount of grease shonld be used for lubrication, and if they used an oil or a grease which contained anything of an acid nature it might eat through the galvanizing and injure the wires. The wires tested in his experiments were taken from the cap-end, as being the worst part of the rope, as he considered that if that part were in good condition the other part would be perfectly safe. In the torsion-tests there was a small falling off—about 2 per cent. in the strength, due to galvanizing, but there was another way to look at it. Supposing they used a rope made of plain wire which would probably be safe up to 2 years, if by galvanizing or any other means the ropes could be run longer and were in good condition when taken off, this small loss was not so serious as it looked on paper. The zinc could be peeled off by bending the wires, but he asked the members whether that was a fair test, and whether it compared with the conditions under which a winding-rope

worked over large drums and pulleys. A torsion-test was only used by manufacturers for comparing the temper of different wires when new, and great judgment was required in testing by torsion, which ought always to be taken along with tension and bending so as to arrive at the condition of a rope at any period of its life.

Mr. M. WALTON BROWN (Newcastle-upon-Tyne) wrote that the processes of pickling and galvanizing must necessarily reduce the torsional strength of iron or steel wire, but the tensile strength is not so much affected. A slight decrease of strength occurs during the preliminary process of pickling (during which the wire is placed in a solution containing 12 per cent. of hydrochloric acid) owing to the acid penetrating into the wire, but this source of decreased strength is destroyed when the wire has been passed through the hot zinc bath. In galvanizing, the wire is passed through the bath at a speed which allows the wire to almost attain the temperature of the molten zinc, the wire being continuously wound through the pickling trough and zinc bath. Sal-ammoniac is thrown on the top of the molten zinc, and acts as a flux. Wire of high breaking strain will be reduced in hardness and tensile strength by the alteration of temper and the formation of a zinc-iron alloy by the passage of the wire through the bath of molten zinc, with a temperature of about 1,000° Fahr. If the temperature of the bath be kept at 775° Fahr., the solidifying point of zinc, and the wire is rapidly run through it, the zinc is deposited on a slightly heated wire, and the zinc is not closely adhesive to the iron or steel, and readily crackles off by bending or twisting. The crackling of the zinc-coating may be avoided if care be taken to vary the temperature of the zinc bath, so as to suit the various sizes of wire passed through—thick wire requiring a greater heat than small wire. The use of an improper temperature is easily detected by observing the colour of the wire passing through the zinc bath, a blueish tinge being given to the wire when the bath is overheated; and when the temperature is too low, the wire leaving the zinc bath is of a paler colour, and the coating of zinc is uneven. The thickness of the zinc-coating adds about $\frac{1}{4}$ of a gauge to the size of the wire, and 5 per cent. to its weight. The surplus zinc is removed from the wire by means of a mechanical arrangement consisting of a bed of damp sand built up at the end of the zinc bath; the wire is borne down and passed through the sand, preventing the running of the zinc into drops on its surface, and at the same time giving a polished appearance to the wire,

which is then ready to be passed away in coils for use. The surplus zinc may also be wiped off the wire by means of asbestos rubbers.

Mr. A. H. STOKES, in moving a vote of thanks to Mr. Lees for his paper, suggested that Mr. Lees should test the wires by putting them in various waters, taking them out and letting the atmosphere act upon them. Unfortunately, breakages, sometimes accompanied by loss of life, occurred; and occasionally the ropes which broke were only a few months old. Then when such accidents were investigated and the broken part of the rope opened, a serious deterioration of strength due to internal corrosion was discovered. If galvanization of ropes would obviate this defect, it would be a great benefit.

The PRESIDENT, in seconding the resolution, supported the suggestion that Mr. Lees' experiments should be extended, and any addition which could be made to their stock of information on the subject would be of great advantage.

The vote of thanks was cordially adopted.

Mr. T. G. LEES said that he would make a few experiments as to the action of various waters upon galvanized wire-ropes, and communicate the results to the members. He might, however, state that he had learnt from different ropemakers—and they all made the same statement—that while they had investigated many breakages of wire-ropes from internal corrosion, they had never heard of the breakage of a rope made of galvanized wire from that cause.

DISCUSSION UPON MR. T. G. LEES' PAPER ON "EXPLOSIONS IN AIR-COMPRESSORS AND RECEIVERS."*

Mr. C. J. OLIVER enquired what jointing material was used through which the sparks passed.

Mr. T. G. LEES replied that indiarubber insertion was used.

Mr. HENRY FISHER wrote, that the makers, Messrs. Walker Brothers, had for a long time considered the air-compressor at Clifton colliery to be obsolete, and to effect a lowering of the temperature of the compressed air from that shown in the paper, they had on several occasions recommended that the air-compressor should be altered so as

* *Trans. Inst. M.E.*, vol. xiv., page 554; and vol. xvi., page 14.

to compress the air in two stages instead of one, and also that the old forms of inlet-valves and discharge-valves should be replaced by modern valves of larger area and improved construction. He had been supplied with the following particulars from observations made with a two-stage air-compressor, manufactured by Messrs. Walker Brothers, working at a colliery in South Wales. The initial temperature of the free air was 63° Fahr., and when the pressure of the compressed air in the air-receiver was 75 lbs. per square inch, the temperature was 240° Fahr. The theoretical temperature of air at a pressure of 75 lbs. per square inch being 420° Fahr. for the same initial temperature of 63° Fahr., the observation shows a cooling of the air during compression of 180° Fahr. As the temperature of compressed air produced by two-stage compression is very much lower than that produced by one-stage, the former method is to be preferred, as greater efficiency and safety are thereby secured.

DISCUSSION UPON MR. L. W. DE GRAVE'S PAPER ON "PHOTOGRAPHS OF FLASHES OF ELECTRIC DETONATORS."*

Mr. A. H. Stokes said that recently he asked whether a detonator would fire gas or an explosive mixture.† Before that remark was published in the *Transactions*, great surprise, indeed, was expressed by a writer in the *Colliery Guardian*, that one of H.M. inspectors of mines should have asked such a question, which was described as a "striking instance of unwisdom" on the part of the inspector. The writer proceeded to argue on the molecular construction of flame and gases and to show by certain measurements—hypothetical measurements—that it was quite impossible that the flame from a detonator could fire the gases. Unfortunately for that gentleman's calculations and theory, Mr. de Grave had (Fig. 19, Plate X., vol. xv.), shown that a detonator had exploded a gaseous mixture, an actual experiment convincing to the practical man. Mr. de Grave had gone further, and with a No. 8 detonator had fired coal-dust. These instances were mentioned to show the value of Mr. de Grave's experiments, and nothing could be plainer, clearer, and better than his paper.

Mr. J. B. Smith said he had no doubt that a detonator would fire gas. He noticed from the experiments that detonators containing most

* *Trans. Inst. M.E.*, vol. xv., page 203. † *Ibid.*, vol. xv., page 206.

fulminate of mercury gave the largest flame, and he did not think it mattered much as to whether they were high or low tension. He should like to see two detonators fired side by side, so as to ascertain whether there was a collision of flames in the photographs.

Mr. M. DEACON considered that the questions raised by the paper were of vast importance. During the discussions which took place some 2 or 3 years ago and prior to the issue of the Home Office order, he frequently stated that he had fired coal-gas with detonators, and he asked what was the precise object of arriving at an explosive which would give a slightly less intense flame than another, when the detonator itself would fire the gas. The subject being raised again brought the question forward once more: What was the object of having an absolutely safe explosive, if a detonator would fire the gas?

Mr. W. MAURICE remarked that Fig. 18 (Plate X., vol. xv.) showed that a fragment of copper would raise a spark when struck against cast-iron under certain conditions. The detonator was suspended from an iron window-frame as shown in Fig. 17, and the bits of copper might still be found fused on the frame in the positions indicated by the reference-letters, A, B and C, in Fig. 18. He thought that this fact rather told against the suggestion that the sparks resulted from secondary detonation of particles of fulminate of mercury. Fig. 19, concerning which Mr. Stokes had made some observations, was an interesting photograph; but, speaking for himself, he was not at all disposed to regard it as conclusive evidence that a detonator would fire a mixture of pit-gas and air. All recent researches tended to show that conclusions drawn from experiments with coal-gas, on the strength of its assumed identity or equivalence of composition with that of pit-gas, were of no value.

Mr. M. WALTON BROWN wrote that, during the course of the experiments of the Explosives Committee of the North of England Institute of Mining and Mechanical Engineers, experiments were made in July and November 1893, and January and December 1894 with high-tension detonators: 4 ignitions occurring in 25 experiments with coal-gas mixtures and 2 ignitions in 25 experiments with pit-gas mixtures.*

The further discussion of the paper was then adjourned.

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* *Report of the Proceedings of the Explosives Committee of the North of England Institute of Mining and Mechanical Engineers*, 1896, pages 27, 28 and 77.

MEMOIRS OF DECEASED MEMBERS.

Mr. George Crompton, a member of an old and wellknown Derbyshire family, was the younger son of the late Mr. Gilbert Crompton, of Flower Lilies, Windley, Derby, and was born at Chesterfield on October 13th, 1823. He was educated at Rugby, where he was one of the favourite pupils of Dr. Arnold. As a partner in the bank of Messrs. Crompton, Newton & Co., and afterwards as a director of Crompton & Evans' Union Bank, he resided for some years in Chesterfield, but will be best known in Derbyshire as the head and mainspring of the Stanton Ironworks Company. Circumstances having thrown these works into the hands of the family in 1856, Mr. George Crompton at once set himself to the task of mastering what was to him a new business. Bringing all his energy and ability to bear on the enterprise, and greatly assisted and supported by his elder brother, Mr. John Gilbert Crompton, he succeeded in extending the comparatively small business carried on at Stanton-by-Dale to its present magnitude, giving employment to upwards of 5,000 workpeople, and associating with the manufacturing works extensive collieries, and also ironstone-mines in Northamptonshire, Lincolnshire and Rutlandshire. The chief point of interest in this connexion is, that two gentlemen entirely ignorant of iron-making (Messrs. J. G. and G. Crompton) should have been able to learn the trade, and build up one of the largest and most successful business concerns of the kind, not having any previous education in this line, simply good business capacities, and abundant application, attention and integrity.

Of the late Mr. Crompton's private life it is needless to say more than that his sweet temper, never-failing courtesy and conciliatory manners in his intercourse with his fellow-men, caused him to be beloved alike in the family circle and by the numerous workmen by whom he was surrounded. Of a modest and retiring disposition, the deceased gentleman did not take a prominent part in public affairs. For several years he held the office of treasurer for the county of Derby, and this position prevented him from being placed on the Commission of the Peace. Mr. Crompton left a widow, four sons and two daughters. He died at his residence, Stanton Hall, on November 14th, 1897. The interment took place in the churchyard of the village of Stanton.

He was an original member of this Institution, and continued a member until his death. During the first 10 years after its formation he

was a vice-president, and on several occasions aided its objects by his presence and contributions, notably in connexion with the Stephenson Memorial Hall.

Mr. ROBERT PLOWRIGHT was born at Portsmouth on June 18th, 1838. He was educated at the Diocesan School and Naval College, Portsmouth, and received his professional training at the Government steam-factory in that town. At the age of 21, he entered the service of the Royal Mail Steam-packet Company as junior engineer, and was employed in the West Indies and other parts until 1861, when he proceeded to Russia to join his father, who at that time was chief-engineer of the Imperial steam-factory at Cronstadt. He remained in St. Petersburg for about 2 years, when he received the appointment of engineer-in-chief of the Shepeloffsky Ironworks in the governments of Nijni-Novgorod and Wladimir. These works are of great magnitude, comprising eleven distinct ironworks; and the smelting and rolling of finer brands of charcoal iron, together with river-steamer and engine building, were very successfully carried on under his direction.

In 1878, he left Russia, and together with his brothers commenced the business of engineers and ironfounders at the Brampton works, Chesterfield. At these works specialities in connexion with colliery and gold-mining appliances have led to considerable development. He joined this Institution as a member in September, 1891. He died at Brampton on May 13th, 1898, and was buried in the churchyard of St. Thomas, Brampton.

Mr. WILLIAM TATE was born at Cramlington collieries, Northumberland, on October 19th, 1838. He served his apprenticeship at these collieries, passing through all grades of the engineering department, and as a result of his energy and thorough knowledge received an appointment as engineer. About 1863, he was engineer at the Thornley and Ludworth collieries, Durham, during the sinking of the Wheatley Hill pits belonging to the same company. In that connexion he made all plans and specifications for the surface-plant, the erection of which he also superintended, laying out the works with great skill. He was engineer at the Cannock and Rugeley collieries, Staffordshire, until 1873.

From 1873 to 1880, he was the mechanical engineer at the Blackwell collieries, near Alfreton. He was engineer for about 12 months at the Monk Bretton colliery, Barnsley, and ultimately attained the management of that colliery up to 1886.

From 1886 to 1893, he was manager and agent at the West Ardsley collieries, near Wakefield, where he made great improvements in screening and banking coal, introducing the shaker-screen, travelling-belts, air-compressing machinery, and coal-cutting by machinery on a large scale. For a short time he undertook the management of the Oakthorpe colliery, Ashby-de-la-Zouch.

In 1894, he became the lessee of the Measham Main colliery, near Atherstone, an undertaking that, owing to adverse circumstances, did not come up to expectations, and ultimately caused him much trouble. He died at Measham on December 3rd, 1897, from failure of the heart's action.

In his early days he was noted for undertaking sinking, and laying out new and extensive plants. Till within 2 years of his death he was a man of strong physique, indomitable perseverance and high courage, and was considered a mechanical engineer of great skill and judgment on all mining matters. He was an inventor of miners' safety-lamps, and brought out a number of ingenious methods of closing gates at the top of upcast winding-shafts and in changing decks simultaneously. He was of a genial disposition, and gained a large number of friends in ranks of life both above and below him.

He became a member of this Institution on July 7th, 1875.

Mr. George Butterworth was born at Danesmoor, Clay Cross, on May 13th, 1839. He served his apprenticeship in a carpenter and joiner's shop at Pilsley, after which he was at Matlock for a short time. He came to Clay Cross on March 25th, 1863, and was employed by the Clay Cross Coal and Iron Company as a carpenter. On account of his exceptional abilities and strict attention to duty, he was appointed head foreman over the mechanics and labourers on November 6th, 1872, a position which he held until his decease: this occurred suddenly at Clay Cross on February 14th, 1898.

He had been an Associate of this Institution since September 6th, 1893.

The following paper on "Electric Blasting (Part IV.)" by Mr. William Maurice was taken as read:—

ELECTRIC BLASTING.

By WM. MAURICE.

Part IV.*

In the preceding sections of this paper, attention has been mainly devoted to what may perhaps be considered abstract aspects of electric blasting.

In this, the concluding contribution, an attempt is made to approach the subject from a thoroughly practical standpoint, in the hope that the results of recent years' experience, herein related, may prove of immediate service to those who, having hitherto had no occasion to study the matter, are now somewhat at a loss as to which method of electric shot-firing offers the greatest safety and economy in actual underground work.

It has been suggested that too much attention has been paid to the historical side; but, apart from the hitherto existing need of collected information on a subject of growing importance, it is believed that a careful study of the previous papers will disclose the main groundwork of the art under consideration and thus prove slightly more than a mere introduction to the present contribution.

It is proposed, first of all, to describe, with such detail as may appear desirable, representative patterns of each class of electric exploder. By taking examples of British, American and Continental design, it is hoped that members residing either in this country, or in other parts of the Empire, may find herein a convenient reference to any type of machine that they may have at hand.

As with coal-cutters so with exploders: no one type can be considered "the best": each has advantages and disadvantages, which make it suitable or unsuitable, as the case may be, for any given range of work. At the present time, dynamo- and magneto-exploders, primary and secondary batteries, and (particularly in shaft-sinking operations) electrical energy obtained from lighting or power-mains, situated on the surface of the mine, are all employed as electric fuze-igniters; and each class is considered *seriatim* in the pages immediately following.

* *Trans. Inst. M.E.*, vol. xiv., pages 142 and 445; and vol. xv., page 189.

Dynamo-Exploders.—These are practically dynamos in miniature, the armatures of which can be revolved by a rotary crank, a pull-over lever, or a vertical rack-bar, geared direct, or into a train of wheels in contact with the armature-spindle. The fundamental working principle of dynamo-exploders has already been explained.* It now, therefore, only remains to describe individual peculiarities and certain special adaptations for particular purposes.

In Fig. 61 (Plate IV.) a sectional view of a New York (U.S.A.) machine, known best, perhaps, as the Macbeth pull-up exploder, may be seen. Rotary motion is obtained in this design by pulling upward on a handle. In order to steady the machine, it is provided with projecting flanges, *k*, on which the operator may place his feet, so that by his weight he holds the machine down firmly in place, while he is enabled to exert his strength to the best advantage in an upward pull. By this act, the armature is revolved through the mechanism about to be described, thereby exciting the field-magnet and sending a suitable current over the line. Within an enclosing box *A* (Fig. 61) is mounted the exploder proper, *B*, and the mechanism for driving it. So far as the purely electrical portion is concerned, it consists, as usual with dynamo-exploders, of a pair of small electro-magnets wound with series exciting coils, and having an armature, *a*, revolving in the polar gap of the field. On the shaft, *b*, of this armature is fixed a pinion, *e*, with which meshes a driving gear, *d*, fixed to another pinion, *e'*. This latter pinion is engaged by a sector, *C*, carried by a vibrating arm, *D*, fixed on a rocking-shaft, *E*.

The outer end of this arm is connected by a link, *f*, with a vertical sliding pull-up bar, *F*, which passes out through the top of the box, and carries a handle, *G*; being guided in its vertical motion by a tubular bearing, *g*. By pulling upon the handle, *G*, the arm *D* is swung from its lower position (as shown in the figure), and causes the sector *C*, through the train of wheels, to drive the armature at a multiplied velocity. At the extreme upstroke of the handle, the sector passes out of gear with the pinion *e'*, permitting the armature to revolve freely.

In order to accomplish this result, the sector (the tooth-pitch of which, when in the normal engaging position, is in the arc of a circle concentric with the axis of the shaft *E*) is itself pivoted to the arm *D* eccentrically on a pivoted stud, *h*, whence, by turning on this stud, the sector-teeth are brought out of gear with the teeth of the pinion. In operation, the rotation of the armature under its momentum continues

* *Trans. Inst. M.E.*, vol. xiv., page 160.

until stopped by friction, after which the handle will be released and dropped back to its place. During this return movement, the sector will also fall back into its lower position. If the handle be dropped back quickly, the sector, in falling, will remain out of contact with the pinion, but, if lowered slowly, it will drop against, and its teeth will click over the latter as it moves down.

These pull-up blasting-machines are primarily intended for firing low-tension fuzes in considerable numbers, ranging from 20 to 100 simultaneous shots according to the dimensions of the machine. To fire with a pull-up exploder, connect the firing-line to the two terminals, stand on the projecting iron flanges at the bottom of the box with both feet, then pull up the bar quickly, with one continuous stroke. The explosion will then take place. It should be noted that the bar is all the way down, when starting to pull. The quicker the pull, the greater the electrical pressure generated.

The American machines of Mr. H. Julius Smith are familiar to many in this country under the name of rack-bar exploders. In modern patterns, a number of improvements have been effected in details, some of which may be noted by reference to Figs. 62 and 63 (Plate IV.). It will there be seen that the circuit-breaking key is placed in the top of the wooden containing case : this change having been made in order that it may be kept always dry, and easily accessible for cleaning. A rod, *H*, is also provided for guiding and steadying the rack-bar, *I*, as shown in the front elevation, Fig. 63. It is a wellknown fact that the field-magnet and armature of a small dynamo may be quickly brought to the point of saturation, and that, when the current is at its maximum, the breaking of the circuit causes the entire induced current generated in the coils to be discharged, either through the air at the point of rupture of the current, or through a derived circuit connected with the terminals of the field-magnet. In the exploder under consideration, advantage is taken of this knowledge, and also of the fact that an accelerated is more effective than a uniform rotation of the armature in bringing about magnetic saturation. The mechanism of a rack-bar exploder is as follows :—A field-magnet, *J* (Figs. 62 and 63, Plate IV.), is formed with soft iron pole-pieces, *P*, secured to a yoke, in any usual way, and wound with a predetermined quantity of insulated copper wire. The polar extremities are bored out to receive a Siemens I type armature. Upon the end of the armature-shaft, *b*, is placed a commutator, *h*, which is touched on diametrically opposite surfaces by a pair of com-

mutator-springs (or brushes) (not shown in the illustration), secured to, but insulated from, the yoke. Upon the opposite end of the armature-shaft, between the armature and the yoke is placed a pinion, *d*, provided with a series of ratchet-teeth, *n*, on its inner face. These are adapted to engage similar but oppositely arranged teeth, formed on the end of the armature. Between the pinion and the yoke, there is placed a spiral spring, that tends to press the former forward into engagement with the ratchet-teeth, *n*, of the armature. A rack-bar, *I*, passes through the top of the casing, *A* (which supports the dynamo), and extends downward towards the bottom of the box. At the lower extremity of the rack, there is a right-angled arm, *i*, extending from the side of the rack opposite the teeth, which is drilled to slide on a guide-rod, *H*: the latter being secured to the top and bottom of the casing, parallel with the path of the rack-bar, *I*. The latter passes between the yoke and the end of the armature, and is held in gear with pinion, *e*, by a roller, *j* (Fig. 63), journaled in the yoke, behind the rack-bar. The upper end of the bar, projecting above the top of casing, *A*, is provided with a handle, G^1, by which it is moved; and a pin, *p*, is inserted between the handle and the top of the casing, and allowed to project a short distance from each side of the bar. A spring-key, *s*, forked at its free end, and embracing the rack-bar below the pin, *p*, is secured to the top of the case. A bridge, *L*, extends over the spring-key, and is fitted with a contact-screw, *c*, which normally touches the back of the key. The armature is wound in the usual way, and the two ends of the winding are connected respectively to each half of the commutating-cylinder, *h*. The springs (that is the brushes) which make contact with the surface of the split-cylinder, are joined in series with the field-magnet winding, and the free ends of the latter lead to the binding screws, T^1, T^2, upon the top of the containing case. The terminal, T^1, is connected electrically with the key, and the terminal, T^2, with the bridge. By means of this arrangement of the circuit, the field-magnet and armature are normally short-circuited. The terminals, handle, and key are enclosed by a cover, *M*, hinged to one side of the box, and shutting down over them. The cover, in turn, is secured in a closed position by a lock, *N*, and provided with a handle, *G*, wherewith to carry the machine.

In the operation of firing, the handle is raised, thereby rotating the pinion, *e*, on the armature-shaft without turning the armature: a clutch-connexion being arranged for this purpose. On pushing down the rack-bar, a quickly accelerated rotary motion is imparted to the pinion, thereby rotating the armature and generating a current which passes

through the field-winding, screws, plates, key, contact-screw, and yoke. Very little current passes along the external circuit owing to the comparatively low electrical pressure, and the high resistance of the firing-line. The current produced in this manner increases rapidly as the rack-bar descends, and excites the field-magnets and armature to saturation—or approximately so—just before the bar reaches the extreme limit of its downward travel. At the point referred to, the pin, *p*, strikes the spring key, *s*, and breaks the electrical connexion between the screw, *c*, at the instant the maximum current is reached, so that the extra induced current from the field-magnet and armature-windings is forced to pass through the external circuit, thus igniting the fuze included therein, and bringing about the explosion of the charge.

As is wellknown, the superimposed electro-motive force obtained when the circuit of an electro-magnet is broken is very much higher than that generated in normal working ; and whereas the direct current from the dynamo could not pass through the external circuit owing to the great resistance of the latter, the superimposed electro-motive force readily enables it to do so, as soon as the short circuit is broken.

To fire with a rack-bar exploder, connect the firing-line to terminals, T^1, T^2, raise the handle to its fullest extent, then press down again with one quick continuous stroke.

Another wellknown American machine is illustrated sectionally in Fig. 64 (Plate IV.). As in those already described, the armature of a series-wound dynamo is rapidly rotated, and means are taken to shunt the external circuit until the field-magnets are fully excited. The connexions are, thereafter, automatically broken, and the entire accumulated current instantly transferred, in its full volume and intensity, to the outside or firing circuit. The rotation of the armature, in this example, is effected by means of a toothed segment, *C*, through the medium of the gearing shown. The toothed face of the segment is so proportioned in length relatively to the circumference of the pinion, *e*, that the traverse of the former on the pinion will operate to rotate the latter through the distance of one complete revolution only, on its shaft. A ratchet-and-pawl mechanism (not shown) works in connexion with a clutch device, so that when the segment rotates the pinion in the direction of armature rotation, the gear will also be turned ; but when operated in the reverse direction by the segment, the clutch will disengage the gear, and the latter remain idle. The actuating-bar, *G*, is so arranged that when not in use it may be slid downward in the hub, *l*, and be practically enclosed within the case, as indicated by the dotted lines in Fig. 64.

To fire with this exploder, connect up the firing-line to the terminals, T^1, T^2, and slide the bar, G, upwards through the slot, n, in the case-lid. It will then fall in the position indicated in the figure; the shots being then fired by a rapid horizontal pull from the limit of movement at one end of the slot to the corresponding limit in the opposite direction.

Messrs. Siemens Brothers & Co. (London) recently introduced a new form of dynamo-exploder differing greatly in construction from any of this firm's older types. An end elevation of this machine, which is known as the twist exploder, is given in Fig. 65, and a side view in Fig. 66 (Plate IV.). Inside a strong wooden case, A (Figs. 65 and 66), is firmly fixed a series-dynamo, and on the axis of its armature, a, which is vertical, is fitted a pinion which gears into a wheel, w, mounted by a ratchet-and-pawl coupling on a screw-spindle or twist, O. The latter is fitted to revolve in two bearings, and has rapid screw-threads (similar to an Archimedean drill-stock) engaged by a nut, o, which is on a cross-head connected by two rods, F, F, to a handle, G. These rods, which are carried through guides, project through the upper part of the machine. The nut, o, usually rests on a spring, s, which is strong enough to support the weight of the nut, crosshead-rods and handle, and which makes a contact short-circuiting the terminals, T^1, T^2, through the magnet-coils and armature. On pulling up the handle, G, the nut, o, causes the screw-spindle, O, to revolve, but does not affect the wheel, w, (the ratchet-and-pawl being arranged so as not to engage the wheel, w, with the spindle, C, when it is rotated by the ascent of the nut). On pushing the handle, G, sharply down, the wheel, w, is rotated, causing the armature, a, to revolve rapidly. The armature, by its revolution, generates current which, passing through the coils of the magnet, excites the field, causing generation of increased current, until the nut, o, striking the spring, s, breaks the short-circuiting contact, whereupon the current generated passes by the terminals, T^1, T^2, to the line, and thence to the fuzes.

In using this apparatus, it is first of all necessary to open the lid of the case and fold it back on its hinges, thereby exposing the handle and the terminals, which are connected by suitable conductors to the fuze-circuit. The connexions of the cable with the terminals should not be made until everything is ready for firing, and until all persons have retired to a position of safety. In firing, the handle must first be pulled up slowly as far as it will go, causing the screw-spindle or twist to revolve, but not rotating the armature owing to the interposition of the

ratchet-and-pawl. The operator then pushes the handle rapidly down, causing the twist-gear and armature to revolve. By this operation, a current is generated, as already described, which, at the end of the stroke, is directed automatically into the line, and thence to the fuzes.

A lighter, and consequently more portable dynamo-exploder, which the writer has found very serviceable in stone-drifting, and opening-out work generally, is manufactured by the Walsall Electrical Company, Staffordshire. A perspective view of the machine referred to may be seen in Fig. 67 (Plate IV.). It differs from the other exploders in being shunt, instead of series-wound. This method of winding and connecting the field-magnet coils necessitates running on open circuit to the end of the driving-stroke, and then switching in the fuzes, automatically, of course, as before. The armature is revolved by pulling out the leather strap shown "in" and (in dotted lines) "out," in Fig. 67.

To fire, the generator should be placed on the ground, the line-wires connected as usual, and (with the operator's foot upon the scored metal plate) the handle pulled quickly and steadily to the end of the stroke, at which point only will the fuze-circuit be completed.

A continuous-current exploder, intended for firing a great number of shots simultaneously, appears in side elevation in Fig. 68 (Plate IV.). This ingeniously arranged machine was designed by Mr. Manet, and is manufactured by Messrs. Marcel, Gaupillat et Compagnie, of Paris. The Manet exploder does not differ, in principle, essentially from other machines of the same class, but somewhat novel methods are employed to attain the end desired. As in the American patterns, the external circuit is open on starting; the moving parts are caused to gradually increase their speed until a given maximum is reached; the fuze-circuit is then automatically closed, and the stored mechanical energy transformed into the energy of electric current. The armature consists of two Gramme rings, mounted on a shaft geared to turn at a speed of 2,000 revolutions per minute. One armature-ring is wound with fine wire, and works in connexion with the firing-circuit; the other has thick wire joined in series with the field-magnet windings common to both rings. The automatic devices take up various positions according to the speed of rotation. At starting, *C*'s circuit is in connexion with the field coils, the magnetic flux being then a minimum. After a few revolutions a weak current is set up in the armature, *a*, and passes through the fuze- and bell-circuit. The current at this instant is too weak to explode the fuzes, but sufficiently powerful to ring the bell: thereby indicating that the fuze-circuit is intact. At the given maximum speed, the exciting

circuit is short-circuited, thus intensifying the magnetization of the field. The firing-circuit is closed simultaneously, and the shots are fired. The several circuits are automatically opened or closed by the two heavy balls shown on the left of Fig. 68, which control suitably arranged contact-levers. Under ordinary circumstances, the speed would fall at the moment of firing, and the levers in breaking contact would cause induction-sparks that, it is thought by the inventor, might ignite fire-damp. This possible source of danger is therefore provided against by arranging an electro-magnet to hold up the circuit-breaking switch until the current has fallen below sparking limit. The Manet dynamo is a low-tension exploder, designed to fire the Manet fuzes previously described,* and is carried in an hermetically sealed case.

The peculiar driving mechanism of another exploder, manufactured by Messrs. Siemens Brothers & Company, is shown in the sectional view Fig. 69 (Plate IV.). Its peculiarity is the arrangement whereby an amount of energy is, in the first instance, stored up, and then, by the actuation of an independent detent-lever, caused to drive a dynamo, the moving parts of which in turn make contact with the firing-line and explode the fuze or fuzes in circuit. In Fig. 69, a dynamo, actuated by a coil-spring, or other convenient motor, has its armature-winding connected in short-circuit with the field-coils, through a contact-key or switch, which is also connected with the fuze-circuit in such a manner that, after the dynamo has been driven for a sufficient period of time to produce the necessary current, the key, when pressed, breaks the short-circuiting connection and switches the current on to the external circuit.

Magneto-exploders.—A magneto-exploder consists essentially of an armature, revolving between the poles of a set of permanent magnets The main difference between a dynamo- and a magneto-exploder lies in the fact that the former has electro-magnets, *i.e.*, soft iron or mild steel wound with insulated wire, through which an electric current passes and magnetises the iron; whilst the latter has hardened steel permanent magnets, without field-coils.

Magneto-exploders have been employed for underground shot-firing in British collieries for a considerable number of years. Their use in the Derbyshire coal-field dates back some 25 or more years, as evidenced by the discussion on Mr. Henry Davis' paper read before this Institution on July 4th, 1874 †

* *Trans. Inst. M.E.*, vol. xiv., page 460.

† *Transactions of the Chesterfield and Midland Counties Institution of Engineers*, vol. ii., page 296.

If one may judge by the great pressure under which several makers have laboured to meet the present demand, consequent on the Explosives in Coal-mines Order, magneto shot-firers have lost none of the favour that they found in the judgment of colliery managers.

Messrs. John Davis & Son manufacture a compact and very serviceable exploder. The general scheme of this machine may be gathered by reference to Figs. 70 and 71 (Plate IV.), where a shuttle-armature, a, is shown, mounted in gun-metal bearings, concentrically with soft iron polar extensions P, P^1. The latter pieces, which serve to distribute the magnetic field, are enclosed by the legs of five horse-shoe magnets, arranged with their positive (+) poles together on one, and their negative (−) poles together on the other side, so as to form a powerful compound magnet. A high-armature speed is attained by suitably arranged toothed wheels w, w^1, e, e^1, the main driver being actuated by a detachable handle G. The opposite side of the hardwood containing case carries terminals T^1, T^2, and a firing-key K. A diagram showing the circuit-distribution common to this and other magneto-exploders, is shown in the portion of Fig. 74 (Plate IV.) above the dotted line x . . . y.

Fig. 72 (Plate IV.) exhibits the construction of the wellknown Siemens magneto-machine. This pattern was specially designed to meet the demand for an economical and reliable appliance for industrial blasting-operations. It will be seen that the permanent magnets, of which there are eight in the size illustrated, are inverted, and that the armature is carried at the top of the case. The advantage of this apparently useless modification lies in the greater freedom from vibration secured for the magnets, and consequently less frequent necessity for remagnetisation and repairs. The working parts of each exploder are solidly constructed, as is evident from an inspection of Fig. 72, and are enclosed in a strong dust-proof case of polished teak, which is fitted with a carrying-handle, terminals, and a firing-key.

The Ducretet exploder, of Continental design, represented in Fig. 73, is a four-shot machine, weighing about 10½ pounds. It has six steel permanent magnets, between the poles of which a Siemens armature is rotated through toothed gearing. The armature-coil is connected to each end of the spindle ; one end having an insulated contact-stud c, as shown in the diagramatic sketch, Fig. 74 (Plate IV.). This shot-firer differs from the English models in having a condenser, and in the arrangement provided to ensure safe firing in a gaseous atmosphere. The condenser, consisting of alternate layers of tinfoil and paraffined paper, as

in those already described,* is joined as a shunt to the armature-coil, and acts as a reservoir, which, at the moment of firing, instantaneously adds the whole of its stored charge to that in the armature. In order to isolate the contact-points in the key, *K*, from the air, they are enclosed in a rubber vesicle, *V*, as shown in Fig. 74, thereby eliminating any possible danger from sparks on breaking contact.

Dimensions and weights of various dynamo- and magneto-exploders are given in Table II.

Afluidic Batteries.—As a preliminary to the consideration of afluidic or so-called dry batteries as shot-firers it will, perhaps, be advantageous here to introduce a few notes on the principles involved in the production of an electric current by chemical reaction. Fig. 75 (Plate IV.) represents an elementary primary cell, comprising a containing vessel, a strip of zinc, a strip of copper, and dilute sulphuric acid. The liquid in which the couple is immersed is called the electrolyte. It is absolutely essential to the production of a current that the electrolyte be capable of (1) acting chemically on one of the metals of the couple, (2) conducting the current, and (3) being decomposed during the action of the cell. When the two metallic strips are connected outside the liquid by a piece of copper wire, chemical action takes place, and current is said to flow from the strip at which the chemical action is most energetic to that at which activity is least displayed. If a single cell, such as here described, be set up, it will be observed that many bubbles of gas appear on the zinc, and few on the copper strip; hence it is conventional to say that the current flow is in the direction of zinc to copper, or from the positive (+) to the negative (—) strip. Adhering, for the sake of simplicity, to this convention, let it be supposed that current continues to flow in the same direction, up the copper strip to its terminal, thence through the connecting-wire to zinc, and so to the point whence it is assumed to start. As the binding screw on the copper strip is +, and that on the zinc strip –, this leads to the apparent anomaly that the positive terminal is on the negative strip, and the negative terminal on the positive strip. If, however, it be noted that inside the cell current flows from the positive plate (zinc) to the negative plate (copper), whilst outside the cell current flows from the positive terminal (copper) to the negative terminal (zinc), this little peculiarity in the nomenclature of batteries at once becomes clear.

* *Trans. Inst. M.E.*, vol. xiv., page 154.

TABLE II.—DIMENSIONS AND WEIGHTS OF DYNAMO- AND MAGNETO-EXPLODERS.

Type of Exploder.	Dimensions.		Weight.		Average Number of Fuzes that the Machine will Fire.
	Inches.	Millimetres.	Lbs.	Kilogs.	
Dynamo-exploders—					
Siemens twist	14½ × 8⅛ × 5¾	368 × 206 × 146	26¼	12	25 high-tension in parallel. 40 low-tension in series.
Manet	8¼ × 8¼ × 10¾	210 × 210 × 270	22½	10	
Rack-bar No. 4	17½ × 9½ × 6½	444 × 241 × 164	42	19	26 high-tension in parallel. 35 low-tension in series.
,, No 3	8⅛ × 5⅜ × 13⅛	206 × 136 × 343	22½	10	22 low-tension in series.
Magneto-exploders—					
Siemens high-tension, Nobel pattern	9¼ × 7½ × 8¼	235 × 190 × 209	21	9½	25 high-tension in parallel.
,, low-tension ,,	,, ,, ,,	,, ,, ,,	,,	,,	10 low-tension in series.
,, high-tension ,,	9¼ × 7½ × 6½	235 × 190 × 164	14¾	6¾	20 high-tension in parallel.
,, low-tension ,,	,, ,, ,,	,, ,, ,,	,,	,,	7 low-tension in series.
,, high-tension ,,	7½ × 6 × 6	190 × 152 × 152	8¼	3¾	16 high-tension in parallel.
,, low-tension ,,	,, ,, ,,	,, ,, ,,	,,	,,	5 low-tension in series.
Davis high-tension	6¼ × 7 × 9¼	164 × 178 × 235	22½	10	20 high-tension in parallel.
,, low-tension	,, ,, ,,	,, ,, ,,	,,	,,	20 low-tension in series.
,, high-tension	6½ × 4½ × 7	164 × 114 × 178	9¾	4¼	8 high-tension in parallel.
,, low-tension	,, ,, ,,	,, ,, ,,	,,	,,	8 low-tension in series.
,, high-tension	5½ × 4½ × 5	139 × 114 × 127	5½	2½	3 high-tension in parallel.
,, low-tension	,, ,, ,,	,, ,, ,,	,,	,,	3 low-tension in series.
Ducretet low-tension	—	—	10½	4¾	4 low-tension in series.
Roburit Fabrik low-tension ...	4½ × 4$\frac{5}{16}$ × 3⅜	115 × 110 × 90	4	1⅘	1 low-tension.

Referring again to the rudimentary cell, it is found that the bubbles of gas (which, if collected and tested, would prove to be pure hydrogen) passing from the zinc to the copper have a tendency to stick to the latter plate. This tendency is, for two reasons, detrimental to the working of the cell. In the first place, the bubbles of hydrogen form a film of insulation, which acts as a counter force, increasing the internal resistance of the cell, and thus reducing the available electro-motive force. Secondly, a further counter electro-motive force is set up owing to the fact that hydrogen has an opposite electrical polarity, in other words, is electro-positive, to zinc, and therefore tends to send a current from itself against the working current of the cell. This gaseous action on the plates of voltaic cells is called polarization. The thousand and one modifications in primary-battery construction have, for the most part, been devised with the particular object of overcoming this inherent defect in the transformation of chemical into electrical energy.

The Leclanché battery (invented by Mr. Georges Leclanché, of Paris, in 1866) has long held a front place in the production of small intermittent electric currents, and in its improved forms is still more extensively used than any other variety. No description of the Leclanché battery need be given, since it is the cell used for electric signalling work in almost every colliery in the country.

It is mentioned here for the reason that so-called dry batteries are Leclanché in principle, whatever they may be in name. These last cells are, however, of comparatively recent invention, in a field wherein Messrs. Minotto, Wolf, Keiser and Desruelles were early workers. Dr. Gassner achieved some measure of success with a design which he introduced in 1888. This cell consisted of a cylindrical zinc vessel, itself forming the positive element, lined inside with a paste composed of zinc oxide, ammonium chloride, and water. A mass of carbon in the centre of the paste formed the negative element.

It was thought at one time that a battery might be constructed somewhat on the lines of the volta dry pile. This pile consisted of similar-sized discs of zinc and copper, interposed with thin layers of card or leather moistened with acidulated water. The series of elements thus arranged were clamped together, and vessels of liquid connected to the ends for the purpose of joining up to other apparatus. The volta pile was devised in 1800. It possesses great historical interest as first indicating a means of obtaining an uninterrupted flow of current in a conductor, but it has no practical value, owing mainly to the rapidity with which it polarizes.

Chemical reaction must take place to produce current in a primary battery, and since this is impossible in the absence of moisture an absolutely dry cell is unattainable. The expression, dry cell, should not, therefore, be taken in its literal sense, but rather as a generic title for all those cells in which the exciting mixture is pasty instead of being fluid, and which are sealed at the top with bitumen, or other convenient preparation. In general, the composition of the exciting and depolarizing mixtures are, so far as the mere production of current is concerned, similar to those employed in a common Leclanché cell, but by varying either (or both) the mechanical construction and proportions of ingredients different makers claim special merits for their particular form of cell. Some makes are further improved by the addition of novel depolarizing agents.

The way has now been paved for the consideration of primary batteries as fuze-igniters. Fluid primary cells may be dismissed at once ; they are troublesome and expensive, and it is questionable whether they possess any countervailing advantage whatever. Afluidic or dry cells have, however, it is believed, distinctly demonstrated their efficiency in underground shot-firing.

Experiments with various makes have been in progress during a number of years, and the writer is convinced that at the present moment a properly arranged system of firing with dry cells constitutes the cheapest, and, all things considered, the most satisfactory method available for exploding single charges in coal or rock.

So far, the best results have been obtained with Obach and E.C.C. dry cells. The Obach, of which Fig. 76 (Plate IV.) represents a vertical section, consists of a zinc cylinder, *A*, fixed on an insulating base, *B*, and containing a central carbon rod, *C*, surrounded by concentric depolarizing and exciting mixtures, covered with granulated cork or equivalent material for preventing escape of moisture ; the cork being sealed in with a layer of bituminous cement. In the illustration, *A*, is a zinc cylinder cemented to a prepared-asphalt base, *B*. Surrounding a carbon rod, *C*, is a depolarizing mixture, *D*, consisting of about 50 or 60 per cent. of manganese peroxide and about 40 or 50 per cent. of plumbago. This is mixed with gum-tragacanth to the condition of a thick paste, which latter is squeezed out of an annular die in the form of a hollow cylindrical column.

A suitable length cut from this column is placed in the cell and centred within the upwardly projecting ring, *b*, of the base, *B*, the carbon, *C*, being previously placed within it. The annular space between

the depolarizer and the zinc is filled in with an exciting mixture, *E*, consisting of about 80 to 90 per cent. of calcium sulphate and 10 to 20 per cent. of vegetable meal, made into a thin paste with a solution of ammonium chloride. The layer, *G*, consists of cork, sawdust or other moisture-absorbent, *K* being the black sealing-compound, through which is fixed a small glass tube, *L*, to allow of the escape of gases.

Captain C. A. McEvoy, the inventor of numerous improvements in electric fuzes and apparatus, has recently designed a simple form of dry-battery holder and firing-key. A small dry cell is enclosed in a cylindrical casing, which can be held in one hand. One end of this casing is closed by an insulating-disc having two metal stems extending outwards from it, each carrying a binding terminal. The opposite end of the cylinder is closed by a metallic screw-cap, through which a cylindrical stem, with a mushroom-head on its outer end, is fitted so as to slide freely. The stem is pressed outwards by a coiled spring, the extent of the outward movement being limited by a head on the inner end of the stem. At the end of the dry cell, opposite to this stem-head, a contact-stud, in electrical connexion with one pole of the battery, is fixed. The mushroom-head is always electrically connected with the metal of the outer casing, and so with one of the binding-terminals, which is also metallically joined thereto. The other battery-pole is caused to make electrical contact with the free terminal by means of a specially devised spring-base. In this way, whenever the mushroom-head is pressed inwards, the end of the contact-pin which it carries is brought against the contact on the end of the dry cell, and the battery-circuit is thereby completed, through any line passing from one terminal screw to the other. In practical application, the operator joins his firing-line to the terminals, and then, by holding the battery-case in one hand and pressing it against himself, the mushroom-head is forced inwards and the firing-circuit completed. A forked safety-key, that may be thrust between the spring-head and the casing, is provided, in order that premature or accidental movement of the head may be prevented.

At many collieries one, two, or three dry cells are grouped together in a pinewood box with a screw-down lid. The outside + and — wires are respectively joined to two terminals bolted through one side of the case, and the exploder is completed by the addition of a handle or sling-strap. In Table III. will be found details of a number of dry cells, from which a selection may be made either for a group as described or, as the writer prefers, a single cell, treated in the manner detailed under the section respecting *Blasting in Coal*.* Messrs. John Davis & Son send out sets

* *Trans. Inst. M.E.*, vol. xvi., page 168.

TABLE III.—DIMENSIONS AND OTHER PARTICULARS OF DRY CELL EXPLODERS.

No.	Type of Exploder.	Dimensions.		Electro-motive Force about	Internal Resistance about	Weight.			Average Number of Low-tension Fuzes in Series.
		Inches.	Millimetres.	Volts.	Ohms.	Lbs.	Ozs.	Kilogs.	
1	Davis 12 cells battery... ...	7 × 4½ × 4¾	178 × 114 × 121	15·0	6·0	8	0	3·63	3 to 4
2	,, 6 ,, ...	5¼ × 2¾ × 4¾	133 × 70 × 121	9·0	3·0	4	0	1·80	2
3	,, 3 ,, *... ...	5¾ × 5¾ × 2½	146 × 146 × 63	4·5	1·5	4	12	2·15	1
4	,, 3 ,, ...	4½ × 1¾ × 4¾	114 × 44 × 121	4·5	1·5	2	0	0·90	1
5	E.C.C. (Burnley cells) ...	3¼ diam. × 8	82 diam. × 203	1·47 to 1·5	0 35	4	3½	1·91	1
6	,, ,, ...	2½ ,, × 7	63 ,, × 178	,, ,,	0·70	2	12	1·24	1
7	,, ,, ...	2¼ ,, × 5⅞	57 ,, × 149	,, ,,	0·85	1	5	0·51	1
8	Obach cell	$2\frac{13}{16}$ × $2\frac{13}{16}$ × 6½	72 × 72 × 165	,, ,,	0·20	3	0	1·36	1
9	,, ,, ...	$2\frac{11}{16}$ diam. × 7¼	68 diam. × 184	,, ,,	0·20	2	12	1·24	1
10	,, ,, ...	$2\frac{3}{16}$,, × 6	55 ,, × 152	,, ,,	0·25	1	6	0·62	1
11	,, ,, ...	$1\frac{15}{16}$,, × 5¼	49 ,, × 133	,, ,,	0·30	1	0	0·45	1
12	,, ,, ...	2 × 2 × 5½	51 × 51 × 140	,, ,,	0·25	1	6	0·62	1

* As in Figs. 77 and 78 (Plate IV.), with 66 feet of No. 22 twin wires.

of dry cells arranged in light japanned cases, with external spring-firing contacts. If, again, it be preferred to have a combination-exploder and cable-reel, there are none of which the writer is aware more compact than the Davis pattern illustrated in Figs. 77 and 78 (Plate IV.). Three cells, each 1½ inches square by 4 inches high, are joined in series within a case of 5¾ inches by 2½ inches by 5¾ inches in external dimensions.

Upon one face of the box there is attached, in the manner shown in the illustrations, a light drum with thin sheet-metal flanges and handle. The drum will hold about 66 feet of No. 22 standard wire-gauge twin wire, insulated in accordance with specification No. 10 (Table VI.).*

The following facts may serve for guidance in the selection of cells to work under any given conditions :—The electro-motive force is the same for all cells of the same type, irrespective of size. The electro-motive force of any number of cells, joined in parallel, is equal to that of one cell only. The electro-motive force of any number of cells, joined in series, is equal to that of one cell multiplied by the number of cells so joined. The larger the cell the greater the number of shots that it will fire before exhaustion ensues. The smaller the cell the greater its internal resistance, and therefore the less energy available for overcoming the resistance of line and fuze. Joining cells in parallel is practically equivalent to increasing the size of a cell. Joining cells in series permits of a greater number of shots being fired simultaneously; or of firing a lesser number over a longer or lighter line.

Secondary Battery-exploders.—In the early part of the present century, the French physicist, Prof. Gaŭtherot, whilst engaged in decomposing acidulated water by passing an electric current into it through the usual medium of two platinum plates, observed an hitherto unnoticed phenomenon. He discovered, in fact, that the platinum plates, if tested immediately after disconnecting from the original source of electrical energy, themselves gave out a feeble current, but in a direction the reverse of the initial current.† It was at first supposed (as it is, popularly, at this moment) that the plates absorbed current during the preliminary or charging operation and gave it up again during discharge. But Prof. Becquerel, at a later date, disposed of this hypothesis, by demonstrating that the returned current was due not to storage of electricity but to the presence of substances having

* *Trans. Inst. M. E.*, vol. xvi., page 156.

† *Mémoires des Sociétés Savantes et Littéraires de la République Française*, 1801.

chemical affinities for each other, derived from decomposition going on during the charge. This returned current is now called the secondary current, and the phenomenon thus briefly set forth constitutes the fundamental principle of secondary cells, also known, in popular language, as accumulators or storage-batteries, or reversible cells.

In passing over early attempts to turn this discovery to industrial use, mention may be made incidentally of the gas battery devised by Lord Justice Grove, and the carbon-acetate-of-lead cell of Dr. C. W. Siemens. These were introduced in 1843 and 1852 respectively, but, while notable as pieces of laboratory apparatus, they did not prove suitable for commercial development. In 1859, Prof. Gaston Planté made a series of experiments with nearly all the metals in common use, in order to determine, if possible, the best couple for a secondary cell. Prof. Planté eventually decided upon the employment of leaden plates, immersed in dilute sulphuric acid. The elements with which Prof. Planté obtained the brilliant results described in his classical *Recherches sur l'Electricité* were arranged with the utmost simplicity. They consisted merely of two long strips of thin sheet-lead, separated from each other by a layer of cloth or felt, rolled up in the form of a spiral, and then immersed in a solution of 1 part by volume of pure sulphuric acid to 10 parts of water. The charging current was obtained from two Grove cells, and was caused to pass into the accumulator, until gas was freely given off from the plates. A current of high electro-motive force, but of very short duration, was obtained from this accumulator, when the charging circuit was broken. An examination of the elements showed that plate which had been joined to the positive pole of the primary cells to have been coated with a thin film of peroxide of lead. The plate which had been joined to the negative pole was scarcely altered, either in appearance or electrical properties. The following simple experiment conveys a tolerably accurate idea of the formation-process and the reactions that take place in a secondary cell :—If two sheets of ordinary lead be placed slightly apart in diluted sulphuric acid, and a current be sent through them, a dark brown deposit will form upon the plate connected to the positive pole of the charging battery, due to the formation of peroxide of lead on the surface of that plate, whilst the other will be reduced slightly to spongy or porous lead. Upon disconnecting these plates from the charging source, and joining through a galvanometer-circuit, a current will be shown to flow from the brown or peroxidized to the other reduced plate. The result of discharging is the reduction of peroxide of lead on the one plate to oxide, and then to sulphate of lead (from the presence of the sulphuric acid in solution), and of the spongy lead on the other to

sulphate of lead. Upon recharging, the anode or brown plate, attached to the positive pole of the charging source, will again become peroxidized, and the cathode or other plate reduced to spongy lead; the sulphate of lead will thus disappear from both plates. The plates are in this manner continually oxidized and deoxidized as they are charged and discharged. In order to produce a cell capable of giving a reversed current for a lengthened period of time a tedious series of operations was, however, necessary, consisting first of the charge, next of a more or less prolonged interval of rest, and subsequently a charge in a direction the reverse of the initial process. These charges and reversals were repeated until the originally smooth sheets were reduced to a highly porous condition, known technically as spongy lead, the object being to increase the amount of active surface on each plate.

At a later date (January, 1881), Mr. Camille Faure sought to avoid this prolonged, and consequently expensive method of preparing secondary plates by applying to them a layer either of spongy metallic lead, or of an oxide, or of an insoluble salt of the same metal. It may be observed that Mr. Treadwell in his recently published *Practical Treatise on the Construction, Theory and Use of Secondary Batteries* claims priority of invention of pasted plates for Mr. R. L. Metzger, who, it is stated prepared them two years earlier than the date of Mr. Faure's invention.

Thus originated two distinct types of secondary cell, the former having plain or Planté plates, the latter Faure or pasted plates. Subsequent researches on the part of other inventors have greatly improved the manufacturing processes and increased the electrical capacity of cells, but the two broad classes still remain. When completely formed (that is, in the condition, practically, in which small cells leave the makers), there is no difference of any moment between a Planté and a Faure cell. Either then consists of two or more plates or grids of lead, one coated with brown or chocolate peroxide of lead, the other with finely divided metallic lead, supposed by some to be more or less alloyed with hydrogen. The latter are conventionally called the negative, and the former the positive, plates. As an explanation of this convention, Mr. Desmond G. Fitzgerald, the wellknown authority on accumulator construction, gives the following rather caustic note:—

> . . . meeting at Paris, when a few gentlemen, more or less unacquainted with chemistry, solemnly decided that the plate supporting the most electro-negative body known—viz., peroxide of lead—was to be called the positive element; whilst that holding as active material a very electro-positive body—viz., spongy lead—was to be called the negative plate.*

* *Electrical Engineer*, 1897, new series, vol. xx., page 774.

Leaving now the theory of the subject, it may be considered to what extent hitherto, and how far secondary cells at the present time, are likely to prove of practical utility for blasting purposes.

Prof. Gaston Planté was, it would appear, the first to propose the use of secondary batteries for the ignition of low-tension fuzes, since he set forth their advantages in this connexion so long ago as 1868 in the *Annales de Chimie*;* and in his *Recherches sur l'Electricité*† he describes, amongst others, a portable accumulator capable of firing several shots simultaneously through 1,000 feet of ordinary galvanized iron telegraph wire.

General Johann von Lauer, writing on electric blasting in fiery mines in the *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, mentions the advantages of accumulators over primary batteries and mechanical generators, and describes a two to three shot-exploder devised by himself. It is composed of a two cells (each of two positive and three negative plates) accumulator, enclosed in a vulcanite case and an outer one of wood, which also contains the firing-key. A safety-fuze is suitably arranged to provide against short-circuiting, through accidental connexion between the firing-wires, and the latter can be joined up for work without opening the box. An incandescent lamp is used to gauge the strength of the battery.

"This system," says General von Lauer, "surpasses all other electrical methods for use in fiery mines, when the number of simultaneous shots does not exceed two or three, since it will fire 1,500 shots in the course of a month without recharging; it is simple and portable, easy to re-charge and repair, and is unaffected by atmospheric changes."

Whilst not going quite so far in advocacy of secondary cells, it must be admitted that they possess a good many of the qualities desirable in an exploder for underground use. It is essential that such an exploder be absolutely safe in any atmosphere; reasonably low in first cost and maintenance; economical and reliable in working; light enough for one man to carry with comfort, in addition to lamp, stick, and firing line; and capable of being easily tested, as a precaution against one source of miss-shots. The main difficulty opposing development in the application of accumulators lies in their especial sensibility to negligent treatment. If, however, they be suitably designed to withstand successfully the rough handling that is apparently unavoidable in underground operations they become almost ideal shot-firers; and, with better knowledge of their

* *Annales de Chimie et de Physique*, 1868, series iv., vol. xv., pages 26-27.

† Pages 14 to 16.

peculiarities on the part of the workmen, they will not improbably become popular sources of electrical energy for this purpose. At present, if economy is to be a primary consideration, a considerable degree of care and attention is absolutely essential, both in charging and application of accumulator-cells.

But although there is yet room for much improvement in secondary cells, it should not be assumed that they are as yet insufficiently reliable for underground use. One of the first difficulties that arose in attempting to provide portable cells, was the necessity for special provision against leakage of the corrosive sulphuric acid. A cell that must always be carried in an upright position is clearly of little use underground. In a shot-firing cell made for the writer by the Bristöl Accumulator Company (London), this problem has been solved in a satisfactory manner by the introduction into the battery of splash-plates and a special form of air-tube.

Portable accumulator-cells, as usually constructed, are provided with an opening in the cover through which the acid solution is poured in. This opening is closed by a plug, and the ordinary provision for ventilation consists simply of a small vent-hole through the plug. The result is that if the cell be laid on its side, or turned upside down, the liquid comes into contact with the plug, closing the means of ventilation, and consequently being forced out through the hole by the pressure of the gas in the cell.

In the battery under consideration, sectional views of which are given in Figs. 79 and 80 (Plate V.), the case is increased somewhat in height, so that a larger space is provided for the accumulation of gas. The orifice in the cover is closed by means of a plug, *H*, which is prolonged at its lower end into a small tube, *J*: the orifice of the tube being continued through the plug. The tube terminates at a short distance above the level of the liquid in the cell; the latter is of such interior dimensions and the tube of such length that, whatever be the position of the cell, the surface-level of the liquid is always below the end of the tube. Ventilation is therefore never interfered with, nor can any escape of electrolyte take place. In the figures referred to, a tube, *R*, open at the lower end, is permanently fixed to the underside of the cover, *F*. The central plug-tube, *J*, has an enlarged end, *S*, having slightly less diameter than the tube, *R*, thus leaving an annular space between them. The tube, *J*, is only bored part of the way down, as shown, and one or more holes, *T*, are drilled through it to meet the end of the bore. Any liquid passing into the tube, *R*, on the reversal of the

cell, cannot gain access to the interior of the tube, *J*, and the chamfered end of *S* facilitates its subsequent escape. The secondary plates, it will be seen on referring again to Figs. 79 and 80, are contained in the lower half of the case, *E*. The shaded portion, *Y*, across the upper edges of the elements, is a splash-plate, intended to prevent or check any splashing of the liquid against the tube. The tendency of the electrolyte to creep is in the Bristöl cell reduced to a minimum, for it has first to travel up the walls of the cell, down the exterior of the permanent tube, then up its bore and so on to the holes in the vent-plug before it can get outside the cell. This cell may be used to fire low-tension fuses either singly, or two in series. With a twin-firing cable of 3/22 standard wire-gauge wire, 90 feet in length, an exploder of the dimensions indicated in the figure will fire about 500 shots per charge.

Figs. 81 and 82 illustrate a small experimental cell constructed by the writer and now in daily use underground. It consists of two pasted (Faure type) and two plain leaden plates, immersed in a gelatinous electrolyte obtained by mixing 3 volumes of sulphuric acid (specific gravity 1·250) with 1 volume of sodium silicate of 1·180 specific gravity. The containing case, *D*, of vulcanite, is enclosed as a precaution against breakage (to which hard rubber is especially liable) in an outer wooden case, D^1. A space, *P*, of about ½ inch between the two boxes is packed with slag-wool.

Fig. 83 illustrates the outward appearance of a small secondary cell as at present generally constructed. The average useful storage capacity of those made by the Bristöl Accumulator Company is stated to exceed 5 ampère-hours per 1 pound of 2 volts cell. This weight includes positive and negative plates, electrolyte, ebonite containing vessel, cover, sealing and terminal wires.

Charging Cells.—It will have been gathered from the foregoing remarks that a cell after having been discharged (viz., when its electromotive force, as indicated by a small voltmeter, falls to 1·85 volts) is useless until recharged from some source of electrical energy. At a colliery, this source will of course be one of the dynamos, and where the pit-bottom is electrically lighted, the re-charging may conveniently be performed in an underground office.

Every secondary shot-firing cell should be tested daily, by means of an accurately calibrated low-reading voltmeter. If the potential difference at its terminals be shown to be 1·85 volts or lower, the cell should be set aside for charging. To this end, the ebonite-plugs are removed and each compartment of the battery is filled with sulphuric

acid, diluted with water to a specific gravity of 1·175 to 1·180. The proper strength is ascertained by means of a hydrometer: that of Beaumé, for example, would read 22 degrees to correspond with the above-named specific gravity.

Cells may be quickly and cleanly filled by the use of the laboratory wash-bottle adaptation of the Bristöl Lamp Company, which is represented in Fig. 84 (Plate V.). After removing the vent-plugs, V^1, V^2, V^3 (one of which is shown in position), the tube, S, is inserted into the vent-holes as far as it will go, and air is blown through the mouthpiece, M. This action causes the acid to rise through the delivery-tube into the compartment, L^1. On its appearance at the vent-hole, H, the operator raises the tube about $\frac{1}{8}$ inch above the plates, as shown in the central space L^2, and draws back until the liquid returns to that level. Each other cell is filled in similar manner.

Having thus renewed the liquid lost by evaporation, the battery is joined to a lighting-circuit, in series with an incandescent lamp, as indicated by Fig. 85 (Plate V.). On 100 volts mains, the proper current will pass for charging a single cell if a lamp of 60 watts, 16 candle-power be inserted in the circuit.

It is important that the polarity of the mains be ascertained before placing a cell in circuit, for a charge in the wrong direction will ruin the plates, if not discovered and remedied very quickly.*

Charging is continued until the electrolyte appears in a state of vigorous effervescence. If the cell is of a design that will admit a small hydrometer the state of charge may be best ascertained with that instru-

* There are several methods of ascertaining the polarity of electrical mains. A direct-reading indicator may be obtained, in which a pointer indicates "positive" or "negative" on a dial when simply joined across the mains.

Another pole-tester consists of a small glass tube, capped and fitted with a terminal at each end. Within are two small knobs, immersed in a liquid. Before using, both knobs are bright; and after using the negative end becomes purple. After a test, the normal conditions are restored, so that the apparatus is always ready for use.

A third method involves the use of chemically-prepared strips, known as pole-finding papers, which are sent out in the form of small books similar to the litmus and turmeric books used in chemical laboratories. To make a test, a strip is torn from the book, damped slightly on the tongue, and the wire extremities applied to it, about 1 inch distant from each other. Some papers show a bright red mark at the negative contact; others a brown mark where touched by the positive wire. Confusion, and consequent mistakes will be avoided however if polarity be ascertained in the following manner:—To one wire leading from a main attach a strip of lead, previously scraped bright all over. Next, attach two short wires to an incandescent lamp (of the kind used on the installation) and join the free extremities to another cleaned leaden strip and the opposite main respectively. If now the two lead strips be held in dilute sulphuric acid for a few moments a current will pass through the lamp and the liquid, and that strip attached to the positive main will be observed to turn brown. (*Vide* experiment previously described on page 144 *ante*.)

ment. A discharged cell may have an acid density of 1·150 (it should not be allowed to fall below this) while during charging the density will gradually rise, until when fully charged it reaches a maximum limit of 1·200. If, as is usually the case with accumulator shot-firers, it is impracticable to make a hydrometer-test, the voltage should be ascertained, remembering that a newly charged cell (of any type except lithanode) gives a voltage 0·5 higher than the normal. This, however, gradually falls off, leaving the normal voltage of 2·0 to 2·1 after the first discharge.

It is desirable that all secondary cells should receive a good charge at least once in a fortnight, even though they may have remained idle in the interim. Cells are injured by being partially charged and then exhausted, but overcharging does no harm. Indeed an occasional charge prolonged for several hours after the electrolyte appears to boil is advantageous, provided of course that the proper current-density is not exceeded. If on applying the back of the hand to a cell-case there is any perceptible warmth, this may be taken as an indication that the charging current is too heavy.

Firing from Dynamo Mains.—It is a not unfrequent practice when driving headings or sinking shafts to utilize current from the nearest available dynamo-mains for fuse-ignition. The presence of such cables affords an efficient and economical method of exploding simultaneous series of either high- or low-tension detonators, and the need of a portable dynamo- or magneto-machine is dispensed with. But it need scarcely be said that, in order to ensure safety, special precautions must be taken in arranging the method of firing; otherwise the practice now being considered is fraught with considerable danger.

Wires may frequently be seen arranged for blasting from dynamo-mains in the manner indicated in Figs. 86 and 90 (Plate V.). Such methods will no doubt serve to fire shots satisfactorily, but unfortunately it is not at all impossible for charges so connected to explode unawares. The insulation of the firing cable inevitably gets more or less injured by flying pieces of rock here and there for a distance of perhaps 30 feet, or even further, from the working-face. Supposing one side of this cable be joined direct to, say, the negative main, and the other through a switch with the positive main, so that a movement of the switch-key is ordinarily necessary to fire a shot. It will be seen from a casual inspection of the diagram that, given a sufficient leakage to earth somewhere on the dynamo side of the switch-main, and

a bare place on the firing-cable lying, say, across a tram-rail, on the other side (Fig. 86, Plate V.), the necessary current to fire a fuze will pass without any contact at the switch. The leakage-current flows from the main to earth, through the bare place in the firing-cable, the fuze, and back to the other main. That such a train of circumstances as those just supposed might really occur, and fire a shot unawares, is more than possible; it is highly probable. The use of a double-pole firing-key (that is, a switch or key which makes or breaks contact simultaneously with both mains) at once frees the operators from risk of premature explosion and the need for special precautions.

A rough test may be made for leakage as follows:—Bare a portion of one main, take hold of it with one uncovered hand, and touch, say, a tram-rail, or the road side, if damp, with the other. A tingling sensation, more or less pronounced will indicate leakage on the other main. Similar procedure with the second cable will indicate leakage on the main first tested. This method obviously is only a rough-and-ready test, and gives widely varying results, with different individuals, according as the skin is moist or dry.

Proper insulation-testing apparatus is rarely available at collieries, but a satisfactory test for earth may be made with a low-reading voltmeter, providing its resistance be known. Connexions are made as shown in the annexed diagram, Fig. 87 (Plate V.), viz., a wire from one terminal of a small voltmeter is joined to, say, the negative main, and the wire from the opposite terminal is joined to earth—care being taken to obtain a good earth-connexion. Deflection of the voltmeter needle indicates leakage on the positive main, because it is due to a current passing from the negative main through the voltmeter to earth, and thence to the positive main per faulty insulation. If the voltmeter be replaced by a low-reading ammeter, the leakage current may be read off direct. A leakage of 0·6 ampère is sufficient to fire a fuze.

Having satisfactorily settled the leakage question, preferably by the use of a double-pole firing-key or equivalent arrangement, a point should be selected at which to make the connexion with the mains. This point will probably be at the junction of a branch with a main road, in the case of underground shot-firing; or on the headgear, in the case of shaft-sinking operations. Shots, of course, might be fired by simply joining the free extremities of the firing-cable to the mains, but such a loose method of procedure is risky to the operators, and if either firing line or detonator fuze be short-circuited, is also liable to blow the safety-fuzes on the mains, or if there be none, to cause damage to some portion of the circuit.

Messrs. John Davis & Son, manufacture an efficient shot-firing key, especially adapted for use on a lighting installation. End and side elevations of this device are shown in Figs 88 and 89 (Plate V.) respectively. It consists of a lock-up case, *A*, provided with a double-pole firing-key, *K*, incandescent lamp, *L*, and automatic current disconnecting-switch, *H*. On opposite sides of the case are two pairs of terminals; one pair leading to the fuzes, the other to the lighting mains. It is immaterial to which side either pair of wires are attached. When ready to fire, the lid, *D*, is opened by screwing in a key, K^1, which should be in the possession of the chargeman or contractor, as the case may be. The switch, *S*, is then turned on by pulling up the lever-handle, after which pressure on the button, *K*, fires the charge. The act of closing the box-lid after firing automatically breaks connexion with the dynamo circuit by pushing down the lever as indicated in the figures. To ascertain whether the apparatus be in good order, preparatory to firing, pull up the switch-lever, hold a piece of metal—a pick-blade, lamp-vessel, or anything handy—against the firing-line terminals, and press the button. If the circuit be intact the lamp should incandesce.

Fig. 90 (Plate V.) illustrates the necessary connexions for firing through an incandescent lamp and double-contact key. An ordinary key has been pressed unintentionally, on more than one occasion; thereby exploding a charge and causing injury to the operators. The pattern shown diagrammatically in Fig. 90 was designed to eliminate this source of danger. It should, however, be observed that it does not remove the leakage risk referred to on the previous page. The object of the key is probably best fulfilled when used in conjunction with a box of primary or secondary cells. The details illustrated in Figs. 91 and 92 (Plate V.) show the action of this special contact maker, which, it will be seen consists of an ebonite tube, *C*, in the middle of which is a metal plate arranged to form a double contact. Two plungers or pushes, K^1, K^2, are fixed at right angles to each other, and one or both recessed below the surface of the tube. It is necessary to press both together in order to complete the circuit.

Mr. Frank Brain devised a system of firing from dynamo mains about 12 years ago. This scheme had for its object the ignition of blasting-charges with absolute immunity from the risk of igniting and exploding any inflammable gas that might be present in the mine. The proposal embodied the use of wires carried along the gateways to the coal-face, and joined at the opposite ends to main cables which extended to any convenient place. A number of shot-holes, in a stall, would be joined in

series or parallel (as the case might require) to the leads, and the charges would be fired simultaneously either from a main-haulage road or from the pit-top. Mr. Brain also designed a sparkless firing-key, which was arranged to break circuit below the surface of a non-conducting liquid.

Conducting-wires.—In order to place a safe distance between a blasting-charge and the operator, it is necessary to employ a suitable length of some kind of wire capable of conveying a current of electricity. Formerly iron wires were used for this purpose, while in those parts of Europe where frictional exploders continue to find employment brass wire is not infrequently the conductor selected. In modern blasting-equipments, however, copper wire is almost universally preferred.

The reason for this will be apparent when it is remembered that the metals vary widely in their relative powers of conducting electricity, or, as it is usually expressed, they have different conductivities. The difference, in fact, between a conductor, which is a substance capable of conveying an electric current, and an insulator, which is a substance incapable (under ordinary conditions) of conveying an electric current, is only one of degree. Table IV. indicates a few substances in descending order of conductivity, commencing with the best known conductor of electricity—silver, and ending with the worst known conductor (that is, the best known insulator)—dry air :—

TABLE IV.

Good Conductors.	Partial Conductors.	Insulators.
Silver.	Water.	Oils.
Copper.	Bodies of animals.	Porcelain.
Aluminium.	Linen.	Wool.
Gold.	Cotton.	Silk.
Other metals.	Hemp.	Resin.
Gas-coke.	Mahogany.	Guttapercha.
Charcoal.	Pine.	Shellac.
Graphite.	Rosewood.	Ebonite.
Strong acids	Lignum vitæ.	Paraffin.
Metallic ores.	Teak.	Glass.
Moist earth.	Marble.	Dry air.

There is probably nothing, except a vacuum, that has not some conducting power. The quality of a conductor, in virtue of which it opposes the passage of an electric current is called its resistance, and in any given wire of uniform cross-section is directly proportional to the length, and inversely proportional to the sectional area of the conductor. From this it is seen that resistance may be increased either by increasing the length, or by decreasing the diameter of a conductor. It is also

increased if any other metal (except silver) be substituted for copper: the relative resistances of different substances being approximately shown in Table V.

TABLE V.—SHOWING THE APPROXIMATE RESISTANCE OF DIFFERENT SUBSTANCES COMPARED WITH COPPER.

Copper	1
Aluminium	2
Zinc (pressed)	3½
Platinum	5
Phosphor-bronze	5⅓
Iron	6
German silver (Cu4, Ni2, Zn1)	13¼
Platinum silver (Pt33, Ag66)	16¾
Platinum iridium (Pt80, Ir20)	18⅓
Manganin (Cu70, Mn12, Ni4)	26
Platinoid (German silver + 1 or 2 % of tungsten)	27¼
Mercury	59
Arc-light carbon	4,400
Pure water at 18° Cent.	2·3 billions.
Bohemian glass	40 trillions.
Ebonite	187 ,,
Guttapercha	300 ,,

The lower part of Table V. serves to show the vast difference in resistance between any of the metals and the substances termed insulators. A piece of guttapercha, for example, offers 300 trillion times as much opposition to the passage of a current as does a piece of copper of equal length and cross-section.

The practical outcome of the fact that a good conductor has a relatively small resistance, and a good insulator a relatively great resistance, is found in the facility with which an easy path may be thereby provided for the electric current, and surrounded with insulation-material to prevent or minimize loss by leakage to earth.

Conductors for shot-firing circuits are composed of single wires, or of a number of wires twisted together to form a small cable. The latter type have the advantage of greater flexibility and consequent lessened liability to rupture in the necessarily frequent coiling and uncoiling of the firing-line. A stranded cable will also withstand blows from pieces of coal or rock and other rough treatment much better than a solid wire, and is in every respect decidedly to be preferred for all blasting-circuits.

These wires, be they solid or stranded, are variously insulated: cotton, jute, paraffin, ozokerite, indiarubber and guttapercha being the materials chiefly employed for the purpose.

For convenience of manipulation, the two wires necessary to complete a circuit are frequently insulated and then enclosed side by side in a strong braiding, the double wire being known as a twin cable. In other patterns, insulated wires are twisted spirally and braided over all in such a manner as to form a circular twin cable.

If one set of strands be laid spirally around the insulation covering an inner conductor, and then braided or otherwise covered over all, a concentric cable is formed.

Details of ten varieties of cable specially suitable for blasting-circuits are given in Table VI., to which the following explanations refer :—

Column I. indicates the size of wire according to the legal standard wire-gauge. No 1 specimen, *e.g.*, is marked 3·22 (sometimes written 3/22), meaning a three-stranded cable of which each wire is No. 22 standard wire-gauge (S.W.G. or L.S.G.). Similarly, 4·25 implies four No. 25 S.W.G. wires stranded together.

Column II. contains details of insulations suited to various classes of work. Nos. 1 to 6 have guttapercha or vulcanized rubber coatings, and are most suitable for use in wet places, or wherever a highly insulated cable is thought necessary. No. 5 is a high-class cable, but is not so well adapted for exposure to weather as the others with similar insulation. It is, however, sometimes strengthened mechanically by the addition of an outer galvanized-wire armouring of sphincter-grip pattern. No. 7 gives particulars of a low-tension firing-cable, which is specially prepared for the writer, and which, after several years' experiments with all kinds, has proved itself the most satisfactory, and, in the end, the most economical for all shot-firing work. No. 8 specification has the same conductivity per unit of length, and is the pattern most commonly employed with low-tension exploders. No. 9 is a concentric cable, the conductors in which are composed of very fine wires. This makes it exceptionally flexible, and well adapted for working off a small reel or drum. No. 10 has two No. 22 standard wire-gauge wires separately insulated and then braided over all. It is suitable for use with a high-tension exploder, but is obviously not so durable as the others enumerated in the table.

Column III.—From the figures submitted in this column, the dimensions of a drum necessary to hold a given length of wire may be ascertained.

Column IV. indicates the resistance per double yard, that is, the resistance per yard out and return, of each cable. Thus, the figures in this column (corresponding to the cable selected) multiplied by the length required in yards gives the total resistance of the cable.

Columns V. and VI. show the weight per double yard, and the number of double yards per pound of cable respectively.

Column VII. gives the metrical equivalents of the figures in Column VI.

TABLE VI.—SHOT-FIRING WIRES.

No.	I.	II.	III.						IV.	V.	VI.	VII.
	Standard Wire-gauge.	SPECIFICATION.	DIAMETERS.						Resistance per Double Yard.	Weight per Double Yard.	Length per Pound.	Length per Kilogramme.
			Wires.		Strand.		Finished.					
			Inch.	Millimetre.	Inch.	Millimetres.	Inch.	Millimetres	Ohms.	Pounds.	Yards.	Metres.
1	3·22	Three-strand conductor, covered with guttapercha to No. 8, longitudinal warps, strong braid, then drawn through preservative composition	0·028	0·711	0·059	1·500	0·240	6·1	0·2650	0·156	6·41	12·9
2	4·25	Flat twin conductor, each covered with guttapercha to No. 12, laid together, taped and braided over all, and served with preservative composition	0·020	0·508	0·045	1·143	0·310 by 0·200	7·8 by 5·0	0·0390	0·065	15·38	31·0
3	3·22	Three-strand tinned conductor, covered with pure and vulcanizing rubber and proof-tape, all thoroughly vulcanized together, braided and served with preservative compound, and then armoured with galvanized wire braiding	0·028	0·711	0·056	1·422	0·192	4·8	0·0265	0·354	2·82	5·7
4	4·25	Four-strand twin circular conductor, each insulated as in specification (3), the two laid together, wormed, braided, and covered with preservative compound	0·020	0·508	0·045	1·143	0·260	6·6	0·0390	0·110	9 09	18·3
5	4·25	As in specification (4), but outer covering consisting of plain cotton braid, without preservative compound	0·020	0·508	0·045	1·143	0·265	6·7	0·0390	0·092	10·87	21·9
6	4·25	Four-strand flat twin conductor, insulated as in specification (4), then laid together, braided, and compounded black	0·020	0·508	0·045	1·143	0·265 by 0·175	6·7 by 4·4	0·0390	0·090	11·11	22·4
7	3·22	Two three-strand tinned copper conductors, each double cotton covered and served, then covered with one layer of pure indiarubber, one of proofed tape, braiding, and preservative compound, and afterwards twisted together	0·028	0·711	0·056	1·422	0·330	8·3	0·0265	0·092	10·87	21·9
8	3·22	Three-strand plain copper twin conductor, double cotton-covered, one layer of pure indiarubber, braided, the two laid together, braided over all, and served with preservative compound	0·028	0·711	0·056	1·422	0·283 by 0·146	7·1 by 3·7	0·0265	0·082	12·19	24·5
9	7·29	Seven-strand plain copper concentric conductor, insulated with pure indiarubber and proofed tapes, braided over all, and served with ozokerite	0·013	0·033	0·013 to each conductor	0·033	0·290	7·3	0·0480	0·085	11·76	23·7
10	1·22	Single-strand plain copper twin conductor, each wire double-cotton covered and paraffined, the two then laid together, braided over all, and paraffined	0·028	0·711	0·028	0·711	0·185 by 0·110	4·7 by 2·8	0·0794	0·030	33·33	67·2

Fig. 93 illustrates specimens of the cables herein described, the numbers corresponding with those in Table VI.

Verification of (1) Exploders, (2) Fuzes, and (3) Circuits.—The facility with which the condition of the several parts of an electric-blasting circuit can be ascertained at any time, up to the moment of firing a charge, constitutes one of the most advantageous features of this method of blasting.

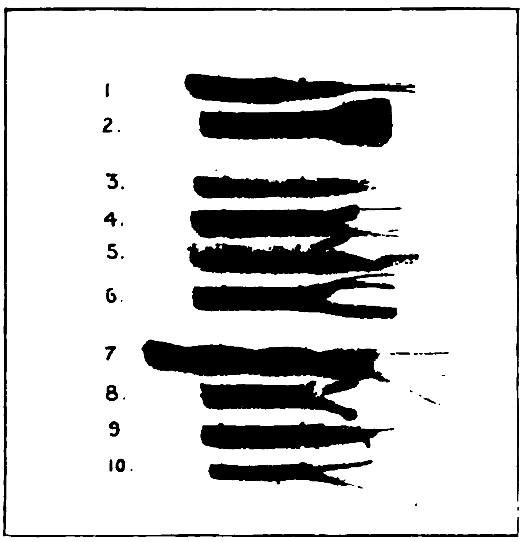

FIG. 93.

With the excellent testing-apparatus now in the market, the operation of proving the working efficiency of an exploder, or a cable, or of determining (more or less satisfactorily) the condition of a fuze, may be performed easily and rapidly, even by inexperienced workmen.

(*1*) *Exploders*, (*a*) *Testing Mechanical Generators.*—Little need be said concerning the testing of dynamo-exploders. They are as a rule exceedingly reliable, and with reasonable care will continue to act satisfactorily until some part actually wears out. Failure may now and again be traced to the commutator-brushes; a simple inspection in this case suffices to indicate the fault—and, of course, the remedy.

Examination will likewise show whether rubbing or dotting contacts have become oxidized—perhaps through remaining idle for some time in a damp place; such a film of dirt may offer too great resistance to the passage of a current, especially in a low-power machine.

The precaution of occasionally applying a few drops of good mineral oil to all moving contacts is, it might be thought, sufficiently self-evident to need no mention. It is nevertheless somewhat unusual to learn of exploders receiving this elementary provision against wear-and-tear—even in those machines specially fitted with oiling-tubes.

The most frequent source of failure in the magneto-exploder is probably loss of magnetism in the steel of the magnets. It is one of the inherent defects of so-called permanent magnets: maximum strength being a condition which cannot be assured for any lengthy period. Vibration contributes, perhaps more than all other normal causes combined, to bring about loss of magnetism; hence it is that these machines should be handled carefully and not dropped on to the ground every time that they are about to be used.

Similar failure may also proceed from other sources less under control, such, for instance, as changes of temperature, slow spontaneous annealing of the steel, and from the effect of a phenomenon known as magnetic self-induction.

Messrs. John Davis & Son have recently introduced an excellent and exceedingly simple exploder-testing device, which fulfils all the requirements of an instrument intended to be used by ordinary workmen. Fig. 94 (Plate V.), almost conveys in itself sufficient information to indicate the manner in which it is applied. It consists of a special incandescent-lamp, carried in a suitable lamp-holder, and enclosed in a small case which has on one side a stout glass disc about 2 inches in diameter, mounted in a bezil. Wires from the lamp are connected respectively with two brass-plate terminals arranged to make wedge-contact with a pair of wires from the exploder that is to be tested. To make a test, the exploder-wires are wedged on the indicator-terminals, the firing-key is pressed, and the handle rotated at normal speed. Satisfactory working condition is shown by incandescence of the lamp, as seen through the disc in front of the instrument. These testers may be used to ascertain the strength of either continuous or alternating-current, high tension or low tension generators but, it need be scarcely observed, the same instrument is not applicable to every machine. To ensure reliability, the makers should be advised as to the kind of exploder with which it is intended to be used.

(*b*) *Testing Chemical Generators.*—A little device identical in principle with that already detailed has been devised by Mr. H. Bonser for the purpose of testing accumulator-cells. The general form of this tester is shown in Fig. 95 (Plate V.), which illustrates a minute

incandescent lamp enclosed in a glass tube having a metal cap over each end. A conducting-wire from the lamp is attached to each brass cap, so that, by merely placing these on the respective positive and negative terminals of a shot-firing cell, the current-strength is indicated by more or less brilliant illumination of the bulb. It should be remembered that a test made in this manner absorbs considerably more electrical energy than is required to fire a fuze, and therefore the instrument should only be applied momentarily. The not altogether unknown practice of holding a tester on a cell "to see the light" is, plainly enough, calculated to frustrate the object of testing by itself exhausting the battery-charge. An illustration showing one of Mr. H. Bonser's testers applied to a small accumulator may be found in his paper on "Improvements in Exploders for Shot-firing," which was read before the Midland Institute of Engineers in 1895.*

Dry-cell exploders, and, it might be added, all other chemical generators, are best tested by means of an accurately calibrated low-reading voltmeter. Knowing that the normal electro-motive force of a single secondary cell is 2 volts, and that of a dry cell 1·5 volts, a simple application of a pair of wires from the terminals of the cell to those of the instrument gives visible indication, by movement of the voltmeter needle over a scale, as to the exact pressure available.

An accumulator-cell showing less than 1·85 volts requires re-charging. A dry cell giving a voltmeter-deflexion below 1 volt should be discarded.

When testing a number of cells coupled together in series, the pointer should indicate a pressure equal to that of a single cell multiplied by the number of cells in the group.

A great number of colliery officials use a detector galvanometer for battery testing. It may therefore be useful to point out that this instrument does not measure pressure, *i.e.*, volts; it merely gives comparative indications of current strength.

(2) *Fuze-testing.*—It appears to be the custom at the present day, whenever discussion arises as to the relative advantages of high- and low-tension fuzes, to give the latter preference "because they can be tested." As a matter of fact it is but little more difficult—given suitable apparatus—to test a high- than a low-tension fuze. But, the writer would ask, where is the *rationale* of fuze-testing when "no deflexion" (of the galvanometer-needle) indicates a bad fuze, and "deflexion" does not necessarily imply a good one? An examination

* *Trans. Inst. M.E.*, vol. ix., page 172.

of the two fuze-heads sketched in Figs. 96 and 97 (Plate V.) may perhaps serve to make this point clear. Suppose, to take example No. 1, that a fuze having a broken bridge, as shown at x in Fig. 96 (Plate V.), be joined in series with a cell and suitable testing-instrument. There is clearly no circuit through the fuze, and consequently no deflexion of the galvanometer-needle; therefore the cap is defective. Now, taking fuze No. 2, which the fates have decreed shall have its bridge short-circuited, as shown at the point x in Fig. 97 (Plate V.). On joining up to the testing-circuit, as before, a deflexion of the pointer is obtained; from which result it might be concluded that the fuze was a good one. But in this case the fuze, unfortunately, is not a good one, for although the bridge is intact, it is acting as a high-resistance shunt to the current, and the probability of its being fired when attached to a blasting-circuit is remote indeed.

The missed shot record, at the collieries with which the writer is connected, stands at 3 failures in 11,800 shots. Of these 3, all of which were recovered and reserved for microscopic and radiographic examination, only one proved to have a severed bridge. All 3 failures occurred, it may be observed, during the first three months in which electric ignition was introduced. The question thus forcibly brought to the notice of the writer was, "Did it pay to waste time and energy in testing nearly 12,000 detonator-fuzes on the bare chance of finding one bad cap?" And when, again, it is considered that a single "bad" cap may be shown by a galvanometer to be a "good" one, the futility of testing becomes even more apparent. On the other hand, there are thousands of detonator-fuzes used daily that are so constructed as to render short-circuiting in the fuze-head almost impossible.

It thus devolves upon the writer to explain briefly the principles and practice of testing.

The appliances required for the purpose of testing low-tension fuzes comprise:—(1) A suitable source of current, (2) some means of indicating current-flow, and (3) adequate protection of the operator from injury caused by untoward explosion of the detonator-fuze under test. If (1) and (2) be judiciously selected, risk of personal injury is reduced to a minimum.

The fundamental requirement may be stated simply as follows:— The apparatus must be so constituted as to be incapable of sending sufficient current through a fuze to cause its ignition. This end can be readily attained, while allowing considerable latitude in choice of

means. Thus, a very weak cell, itself incapable of firing a fuze, may be used in conjunction with a common detector-galvanometer which interposes but trifling additional resistance in the circuit; or, on the other hand, any form of shot-firing cell may be employed in connexion with a high-resistance galvanometer or voltmeter offering opposition sufficient to reduce the battery-current below an intensity at which a fuze might ignite.

As an instance of the first-named variety, a simple form of apparatus occasionally used by the writer may be briefly described. The current-generator in this rough-and-ready tester consists of a leaden paper-weight and a strip of brass, separated by a sheet of blotting-paper saturated with dilute sulphuric acid. The current-indicator may be a freely suspended magnetic needle, enclosed by a number of turns of insulated copper wire. The passage of a current through the coil acts magnetically on the needle, producing movement which varies in direction and extent according to the direction and intensity of current and the number of coils comprising the detector-circuit. Having joined a copper wire between the leaden block and one indicator-terminal, fuzes may be rapidly tested by touching their bare wire-extremities on the free instrument-terminal and brass strip respectively. Proof of metallic continuity of circuit (though, as already pointed out, not necessarily through the bridge) is shown by deflexion of the pointer attached to the current-detector.

Another method of testing is to connect fuzes in series with a Leclanché cell and long-distance electric bell or telephone-receiver. Vibration of the bell-hammer or buzzing in the telephone indicates electrical continuity. Conversely, absence of sound is an indication of rupture somewhere in the circuit, and may be taken to imply a defective fuze-bridge, provided that all other parts of the circuit are known to be intact.

High-tension fuzes, as made by Messrs. Nobel, Limited, are tested with comparative ease by circuiting a current through them from a low-tension magneto-exploder in series with a suitable galvanometer. The exploder firing-key should be temporarily fastened down, and the handle turned slowly when making a test.

Other varieties of high-tension fuzes are not so readily tested, and may, in some cases require apparatus not usually available at a colliery. As a rule, however, the question of conductivity of the bridging composition may be ascertained by means of a long-distance magneto-telephone.

In all fuze-testing operations, personal protection against possible explosion of a detonator is imperatively necessary. It might be, indeed sometimes is, argued that if the testing-circuit is arranged so as to pass only a minute current there is no danger of ignition, but although careful choice of apparatus may do much to prevent, it cannot absolutely assure immunity from, accidental explosion. To cite a single instance of how an explosion might occur unexpectedly, there might be a defect in the fuze-bridge causing a rise of temperature to ignition-point with less current than is normally required to fire the fuze.

Perhaps the best means of providing against injury is to suspend every detonator freely in a piece of iron piping 3 inches in diameter, or in a special iron box whilst being tested. The further precaution of placing other detonators where they cannot possibly be struck by flying bits of detonator-case may be also mentioned.

The writer has exploded disconnected caps at a distance of 4½ inches from an electrically-fired detonator. Further evidence, if any be needed, of the force with which bits of detonator-case strike a distant object is vividly shown in the experiment performed by Mr. L. W. de Grave and the writer, which is illustrated in Fig. 18 (Plate X.).*

3. *Complete Circuit-testing.*—Some exploders carry a self-contained tester, adapted for testing the continuity of a blasting-circuit *in situ*. Two examples of these may be considered, one fitted to a mechanical and one to a chemical generator. The instruments can be of course used also for ordinary fuze-testing, if desired.

(*a*) *Smith Combined Exploder and Circuit-tester.*—The action of the testing device depends, in this, as in all fuze-testers, on the fact that an electric current of definite intensity is required to fire a fuze, and therefore a current of less strength but yet sufficiently powerful to act on a suitable indicator may be passed through it without destroying the bridge. To test a fuze, or a complete firing-circuit, the current generated by the exploder is therefore reduced below the heating-point of the fuze-bridge by passage through a long fine wire, wound upon a bobbin and termed a resistance-coil. The disposition of the coil and the indicator is shown diagrammatically in Figs. 98 and 99 (Plate V.); the former being a side elevation and the latter a plan-diagram of the Smith machine. It has not been thought necessary to indicate in these figures details of the exploder proper, since these are fully described in the text referring to Figs. 62 and 63 (Plate IV.): only such points as are essential to an explanation of the tester are therefore shown. The

* *Trans. Inst. M.E.*, vol. xv., page 206.

electro-magnet, J, consists of cores wound with insulated wire in such a manner as to show opposite polarity on the passage of a current. The polar extremities of the magnet are concaved to receive a rotary armature, which is rotated by the depression of the handle, G, attached to a rack-bar, I; the handle being allowed to rise without turning the armature by a suitable arrangement of clutch-gear.

A fuze or firing-circuit is tested by placing the lever-switch in the position shown in Fig. 99, and joining the terminal wires to the binding posts T^1, T^2. On actuating the rack-bar, an electric current passes from one pole of the field-magnet through wire a to T^1; thence through the fuze or firing-circuit to T^2. From T^2, the current goes by the wire e, through the resistance-coil D, and wire d, c, to the other pole of the magnet, thereby completing the circuit. The interposition of a properly proportioned resistance-coil in this manner permits the passage of a current through the fuze, but not sufficient to bring about its ignition.

The indicating movement consists of an armature S, which is pivoted to the end of the bracket R, in front of the coil D. A bent-wire pointer U is attached to the armature near the pivot. The weight of the pointer tends to keep the armature swung away from the coil D, but on the passage of a current it is attracted and moves the wire a, so that the pointer U comes opposite the glass disc V, in the casing A. Circuit through the fuze is thus shown to be complete. Should the outside circuit be broken there will be no movement of the indicator.

When it is desired to fire the fuze, the switch K^1 is turned into the position shown by the dotted lines in Fig. 99. The pins 1 and 2 are then in metallic connexion through the switch-bar, and the resistance-coil is cut out. Mr. H. T. Smith's exploder, with the improved circuit-tester, is one of the most efficient machines of its class now in use.

(*b*) *Combined Chemical Generator and Tester.*—The instrument to which the diagrammatic illustration Fig. 100 (Plate V.) refers, is a dry battery or accumulator-exploder, with visual and audible indicator. One of a number of useful electrical inventions produced by Major Holden, it finds employment at the present time rather in military than industrial explosive operations. For several reasons, however, it is not without interest to mining engineers. In the first place, it is suitable as it stands, for heavy blasting in shafts; a modified form of the apparatus would make a simple and efficient testing-set and one-shot exploder, for colliery use; and, as the exploder used at the Woolwich Explosives Testing Station it may be exerting one of the side influences on the character of explosion concerning which so little is yet really known.

Captain Cooper-Key has kindly given the writer particulars, as follows, of the set in its present form :—A cubical outer case, measuring about 8 inches each way, contains (1) three storage or Leclanché cells, (2) an electro-magnet of about 80 ohms resistance, in connexion with an armature which, when actuated, causes a red disc to appear outside the box ; and (3) a firing knob which is turned through a $\frac{1}{4}$ circle to test the circuit, and is then pressed in to fire the charge. Referring to Fig. 100 (Plate V.), on turning the testing-knob a contact, k^2, is closed, and a very small current passes around the magnet and actuates the armature. The latter gives an audible click, and also moves the indicator. On then pressing the knob in, k^1 is closed, the electro-magnet is short-circuited and becomes a shunt to the system, and about $\frac{79}{80}$ths of the current passes through the bridge of the fuze and ignites it.

For the further information of those who desire to use the apparatus, the following rules (slightly altered so as to be applicable in mining work) are quoted from an official publication,* written by Major Jocelyn :—

Rules for the detection of the chief causes of failure to fire with electric fuzes: —

(1) If the indicator works properly, and yet when the knob is pressed the detonator does not fire, the fault is a short circuit between the firing leads, or in the fuze itself.

(2) If the indicator works feebly only, some bad joint in the circuit will be the probable cause.

(3) If it does not work at all, the circuit is broken at some point, either in the wires or in the fuze itself.

(4) If the indicator works when the knob is turned, and the charge does not fire when it is pressed, and then, when the knob is turned again the indicator does not work, this shows that the fuze has fired, without igniting the charge.

The apparatus may be considered to be in good order if, on joining the terminals with a short piece of wire, and turning the knob, the indicator works well. If it should only work feebly the battery should be examined, as in this case it will not give sufficient current to fire with certainty.

Blasting in Shafts and Tunnels.—In modern shaft-sinking operations the electrical ignition of fuzes is, or ought to be, the only permissible method. Who does not carry a mental image of at least one, perhaps several, fatal accidents to sinkers, resulting from the use of tape-fuze ? All that may be done with tape-fuze can with equal facility be performed electrically, and with the additional important advantages of absolute safety, greater efficiency, and less cost. There are two systems of connecting fuzes for simultaneous ignition. A set of fuzes may be joined for firing in series or in parallel.

* *Notes on Electricity for the Use of the Garrison Artillery*, page 169.

In the series system, wherein line and fuze wires are all coupled consecutively (as though they were pieces of string joined together to make a long cord), the total external resistance of the circuit is equal to the sum of the separate resistances, or external resistance = Rl + (Rf × N); where Rl is resistance of line; Rf, resistance of one fuze; and N, number of fuzes in series.

In the parallel system, the circuit may be compared to a ladder, the line forming the ladder sides and each detonator fuze a stave. The total external resistance in this system is Rl + (Rf ÷ N). It is thus seen that the resistance varies inversely as the number of fuzes. High-tension fuses, being of high resistance (anything in fact, from 50 to 500,000 ohms, according to the make of fuze), it follows that they may most advantageously be fired in parallel.

The resistance of a low tension-fuze, on the other hand rarely exceeds 1·5 ohms, and most commercial samples average about 0·7 ohm each. They are usually fired in series.

The question as to which system is productive of the least number of missed shots is so dependent on the make and uniformity of the fuzes used that it is not practicable to lay down any rule or distinction.

It being necessary to fire a considerable number of shots simultaneously, in order to obtain the maximum rending effect the choice of an exploder lies between (*a*) electric-lighting or power mains, (*b*) dynamo-exploders, and (*c*) magneto-exploders. The writer would choose between (*a*) and (*b*). Either would, in all probability, prove more satisfactory than an exploder of type (*c*), owing to the tendency of the latter to become weaker with prolonged use.

If system (*a*) be selected the pit-top arrangements will be as indicated in the detailed description of that system.* All firing-connexions should be enclosed in a lock-up box placed in the situation least exposed to atmospheric influences, and preferably under cover. Where there are no electrical-power mains conveniently at hand, a dynamo exploder, with or without combined circuit-testing apparatus, may be employed.

The disposition of the firing-line may be dealt with in several ways. One plan is to suspend a wire on each side of the shaft from stoneware insulators fixed by coach-screws to one of the beams crossing the pit-top. The wires may be bare (hard drawn copper or silico-bronze) if hung clear of the shaft-sides. They are made fast to suitably-placed insulators near the lowest fixed air-pipe, and loose insulated wires are used to make con-

* *Trans. Inst. M.E.*, vol. xvi., page 150.

nexion with the fuze-circuit at the bottom and the exploder at the top of the shaft. This plan necessitates joint-making as the sinking progresses; hence it is not nearly so satisfactory as is the use of a reel on the pit-bank.

With the latter, a suitably-sized drum is selected to hold a length of twin insulated wire equal to, say, $1\frac{1}{2}$ times the projected depth of the shaft. The extra length will allow of injured pieces being cut off, thus avoiding joints in the shaft. An excellent drum for the purpose is shown in Fig. 101 (Plate V.). It consists of a wooden cylinder, having galvanized iron or zinc flanges, the whole being carried between two cast-iron uprights rigidly connected by tie-bars. On each flange there is a brass terminal insulated from it by an ebonite bush. The inside ends of the firing-line are securely attached to the terminal-nuts inside the flange, and the cable is then reeled on to the drum. In operation, the cable is lowered down the shaft by means of the cranked handle, a weight being hung on the end to facilitate its descent. The shots are connected together, the free ends joined to the firing-line, and the men withdrawn from the sump. A flexible cable is then joined from the exploder-terminals to those on the drum-flanges, and the charges are fired. This loose surface-connexion provides an additional safeguard against accidents.

In localities where it is impracticable to obtain a reel of the kind just described, one may be constructed on Mr. C. W. Kinder's model as indicated in Fig. 102, (Plate V.).

In rock-blasting, particularly in the excavations of galleries or tunnels, it is desirable to dislodge several portions of the rock in succession, first breaking that found at the face, and following this dislodgment with the successive breaking of layers progressively further distant from the surface, and to accomplish this at a single firing operation.

With tape-fuze it is easy to arrange each length, so that the shots will follow in proper rotation, but so many accidents have occurred in sinking shafts, where tape-fuze was employed, owing to some hitch in winding-up the kibble after the fuzes had been ignited, that attention has been strongly drawn to electrical methods of obtaining the required retardation.

The wellknown American inventor of blasting apparatus, Mr. H. Julius Smith, has devised a special exploder for firing shots successively, separate circuits being employed for each series, with contacts so arranged in the machine that a limited, though appreciable, space of time will elapse between the ignition of each set of shot-holes. A diagrammatic view of this exploder, with connexions to the rock-face,

is shown in Fig. 103 (Plate V.). The exploder there represented is similar in general construction to the rack-bar machine already described,* but the connexions between the local, or exciting circuit, and the outside, or firing circuit, are arranged to meet the aforenamed special requirements. It will be seen that the bar, *I*, is of such a length that when nearing the limit of its downward movement, the end will strike upon the free extremity of a spring-contact, C^1, and remove the said contact from the terminal-stud, *C*. By this means the current accumulated in the exciting circuit is shifted therefrom to the firing circuit, m, m^1, and fires the low-tension fuzes therein. Further downward movement of the bar by depressing the spring-contact, C^2, causes the current to traverse additional independent circuits, m^2 m^1 and m^3 m^1, successively firing the fuzes respectively interposed therein. The spring-terminals are so arranged relatively to each other, and to the armature operating-bar, that limited, though appreciable, spaces of time will elapse between the passing of the current from the exciting to the several firing circuits. In practising this improved method of blasting, the shot-holes, as shown at Nos. 1, 2, and 3, are located at successively increasing distances from the face of the rock. The holes may, of course, be a succession of single ones, or, as illustrated, a succession of series of holes. The method of utilizing an electric exploder in the manner described, and for this particular system of blasting is fully protected by U.K. patent, No. 3565, 1895.

In June, 1897, the writer witnessed, through the kindness of Mr. Harris Bigg-Wither, some experiments at Gathurst on this gentleman's system of firing shots in definite succession. Mr. Bigg-Wither considered that the most effective way of attaining the desired end would be to light up simultaneously, and introduce some retarding action between the electric fuze and the detonator. This was carried into practice by combining electric ignition with tape-fuze, the retardation being varied by the length of tape-fuze inserted in each charge. In order to ensure certainty of ignition of the tape-fuze, on the combustion of the electric-fuze priming, Mr. Bigg-Wither had tape-fuze prepared with a strand of gun-cotton passing through its outer cover and coming out through the gunpowder-core; this prepared end, of course, being next to the electric-fuze, and attached thereto by means of a paper or metal cylinder. Experimenting on the surface with this system, fifteen detonators have been fired in regular rotation. The first

* *Trans. Inst. M.E.*, vol. xvi., page 130; and Figs. 62 and 63 (Plate IV.).

shot of a series consists of an electric detonator pure and simple, and the same would apply where three or four sumping-shots had to be fired simultaneously; the bench-shots then follow in proper order.

Another method of obtaining a time effect whilst simultaneously igniting a series of shots has been recently devised by Mr. Heinrich Betterman, of Troisdorf, near Cologne. According to Mr. Betterman's method, which is somewhat analogous to that of Mr. Bigg-Wither, the detonator-case (containing any usual charge of fulminate) is separated from the fuze by an additional paper or metal tube. Within this casing there is a piece of tape-fuze or a column of slow-burning powder. Openings for the escape of the gases set free by the combustion of the latter are provided at the electric-fuze end of the extra tube. These openings are, normally, pasted over with paper, which must be pierced before using the fuze. In the application of these fuzes in shaft sinking, for example, an inner circle of sumping shots are provided with detonators of ordinary construction, whilst an outer circle of holes contain the above described time-fuzes. The inner cartridges are exploded directly the battery circuit is closed, but in the bench series there is the momentary delay occasioned by the combustion of the slow fuze.

Blasting in Coal.—In blasting coal, custom at the present time rarely calls for the ignition of more than two or three shots simultaneously. More frequently, a single charge suffices to break in a fast end, or to loosen a web of coal, and leave it sufficiently free to admit of breaking down by wedge and hammer. Much depends, however, upon the local characteristics of the seam, and the method of working; hence it may happen that a system of shot-firing highly successful in one mine may be far otherwise in the workings of another colliery.

As regards single shots, it is fortunate that appliances are available for their ignition much less weighty and bulky than any mechanical generator, though opinions differ as to whether the latter are not, in thick seams and open faces, better in some respects than either of the alternative sources of electrical energy—dry cells or accumulators.

In seams less than about 4½ feet in thickness, or where there is difficulty in keeping the faces open, the weight and dimensions of an exploder deserve consideration; adding considerably as it does to a deputy's impedimenta, checking his progress through the workings, and tending to exhaust his energies before the day's work is over. In mines, of course, where a great number of shots are fired daily, the deputy is (incident to the Explosions in Coal-mines Order, 1897) frequently

relieved of this duty altogether: special men being then appointed to fire shots, and, upon occasion, repair bratticing and other ventilation accessories.

But even in such cases it is advantageous to provide the most portable form of apparatus available, consistent with efficient service. It may, however, be mentioned at once that, for the ignition of high-tension fuzes, none but dynamo- or magneto-exploders are admissible. On the other hand, low-tension fuzes may be effectively fired with a single dry cell, always providing that the product of current, multiplied by the total resistance of the circuit (that is, the internal resistance of the battery plus the external resistance, comprising the line wires and fuze) is well within the value of the electro-motive force of the cell. If no regard be paid to these points it cannot be a matter for surprise to find that the cells run down after firing perhaps only fifty shots, and consequently prove the reverse of economical in working.

Suppose, for example, that, treating the question in an off-hand manner, a dry cell, say 2½ inches in diameter and 7 inches in length, with an internal resistance of 0·7 ohm be selected to fire Nobel low-tension fuzes, through a 90 feet twin wire of No. 20 standard wire-gauge. It can be seen, almost at a glance, that the apparatus is foredoomed to failure, for the total resistance of the circuit (Ri + Rl + Rf) exceeds 3 ohms, and since about 0·6 ampère current is required to fully incandesce a fuze-bridge, it follows by Ohm's Law (electro-motive force = current × resistance) that the electro-motive force (1·5) is barely sufficient to overcome the resistance of the circuit. If, on the other hand, a cell of lower internal resistance, say a C size Obach (with Ri value 0·25ω) be selected, together with a firing-line containing more copper, say a 3/22 standard wire-gauge, this apparently trifling modification makes all the difference between failure and success.

The total resistance in the latter example is as follows :—

	Ohms.
Ri (internal resistance of cell) ...	0·25
Rl (resistance of 180 feet of 3/22 standard wire-gauge) ...	0·79
Rf (resistance of fuze-bridge) ...	0·75
Total resistance ...	1·79

On taking the product of 1·79 × 0·6 (fuzing current), it is found that the electro-motive force required to force that current through the circuit is less than the electro-motive force available at the terminals of the battery; hence this set may be expected to perform its work in an efficient manner.

It need scarcely be said, however, that in order to obtain maximum economy, allowance must be made to compensate for various sources of increased resistance. In the first place, there is the internal resistance

Fig. 106.

Fig. 107.

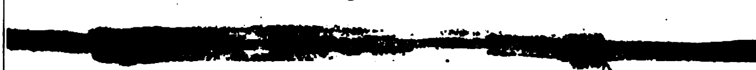

Fig. 108.

Fig. 109.

Fig. 110.

Fig. 111.

Fig. 112.

Fig. 113.

of the cell to be considered. This increases gradually so long as the cell lasts; rapidly, indeed, if it be heavily worked. And, as increased internal resistance means less effective electro-motive force at the terminals of the cell, this alone may render the cell incapable of

firing a fuze. The firing-line, again, may be expected to receive frequent cuts from flying pieces of rock or coal, thus necessitating splices or joints that may or may not add seriously to the resistance, according as they are properly or improperly made. The average underground workman is often accustomed only to splicing mechanical bell wires. This operation he invariably executes as shown in Fig. 106.

The joint may, possibly enough, be mechanically strong, but lying loosely on the ground it cannot be other than faulty, from an electrical point of view, and should be therefore rigorously proscribed in all current-carrying wires. The best method of making a joint in small wires or strands may be gathered by reference to Fig. 107, which shows one partly completed. (A radiograph of a properly made joint, taken through caoutchouc tube insulation, is shown in Fig. 108.) The external appearance of the joint, with rubber tube slipped over and tied, is seen in Fig 109. A damaged cable should, of course, be sent out of the mine for repairs as soon as possible, but it is frequently necessary to make such temporary splices in order that the round of a district may be completed without delay.

Another source of failure against which it has been found requisite to instruct blasters is that of making two splices opposite each other, as shown in Fig. 112, which is reproduced from a piece of cable actually spliced in the manner named underground. If two joints have to be made, it is much better to cut off a foot or so of one wire on each piece. Then on bringing the long and short wires of opposite cables together and splicing, the joints will be separated from each other by insulation.

It may further be noted that if the insulation of a firing-line becomes saturated with water, especially if damaged as shown in Fig. 113, the resistance between the two wires may be so much reduced as to provide an easier path for the current than through the bridge of the fuze. The latter would then, as a matter of course, fail to go off. Other analogous sources of failure in the firing-line will doubtless readily suggest themselves.

Passing now to the fuzes, it is found that they are of somewhat widely varying resistance : from which it follows that a battery and line admirably adapted for the ignition of one make of fuze may be utterly useless with another pattern. The fuzes, for instance, of the Silvertown Company, Limited, have either a platinum-silver bridge 0·0014 inch in diameter, or iridio-platinum, 0·0032 inch : the resistance of the former being 1·65 ohms and of the latter 0·32 ohm. Nobel fuzes (Fig. 23, Plate XXIII.)*, together with the majority of those commonly employed

* *Trans. Inst. M.E.*, vol. xiv., page 464.

in industrial blasting operations (in contradistinction to the fuzes used in the Army and Navy) have bridges 0·001 inch in diameter, with a resistance of about 0·75 ohms. Many German fuzes have platinum wire-bridges 0·002 inch in diameter with 1 ohm resistance; whilst in France those of Messrs. Marcel, Gaupillat & Compagnie (Fig. 51, Plate XXIV.)* have a resistance varying between 140 and 150 ohms, and require a current of about 0·66 ampère at 10 volts pressure to ensure rapid ignition.

At the collieries with which the writer is associated excellent results have been obtained by the use of single Obach cells 6 inches long, $2\frac{3}{16}$ inches in diameter, and 1 lb. 6 ozs. weight (No. 10, Table III.), employed in conjunction with 90 feet firing-lines of 3·22 standard wire-gauge, insulated, etc., as per specification No. 7, Table VI., and Nobel low-tension fuzes of the pattern illustrated in Fig. 23 (Plate XXIII.).† Before sending down the pit each cell has its terminal wire cut off short, then bent outwards and downwards as shown at *x* in Fig. 76 (Plate IV.). If this precaution be not taken it is found that the shot-firers—almost invariably ignorant of the consequences—allow the wire to be brought into contact with the positive terminal, in the manner indicated by the dotted lines in the figure to which reference was last made. The cell, of course, is short-circuited, and if left in that condition for any considerable period of time becomes utterly useless.

To the same end, workmen in charge of shot-firing cells should be instructed not to allow any piece of metal to come in contact with both terminals. This, for example, might easily occur if the cell were put into a pocket containing a knife or nails.

Coal, it may be observed, is a partial conductor of electricity; consequently, if a cell be laid down with both terminals in contact therewith, it would run down, though not, of course, so quickly as in the case of a short circuit through a copper wire.

Missed Shots.—The several apparatus constituting an electric blasting circuit are often, when newly installed in a mine, somewhat analagous to socialistic ideals, in that they may be excellent in themselves but impossible in combination. The exploder may be good, the fuzes may be good, and the line may be good, but if, for example, the resistance of the latter is too great, the exploder (assuming it to be an afluidic or so-called dry cell) cannot overcome the total resistance of the circuit, and a missed shot is the result. Or it may be that the resistance of the

* *Trans. Inst. M.E.*, vol. xiv., page 464. † *Ibid.*

line is such as to pass sufficient current for a few shots, but being too high, and thus drawing heavily on the resources of the cell, it brings about premature failure to ignite a fuze. Whereas a dry battery or secondary cell has only an electro-motive force of 1·5 or 2 volts, against from 60 to perhaps 120 volts in the case of a magneto-exploder, it follows that the former types of fuze-igniters require heavier connecting-cables than those needed for use with mechanical generators.

When the application of electricity to the ignition of blasting charges is introduced into a mine for the first time, it is frequently to be noticed that complaints concerning the number of bad caps are of somewhat constant occurrence. Such complaints are not conducive to the formation of a high opinion as to the merits of the system of shot-firing in question. It would appear, however, that by far the larger number of missed shots, so named, are attributable either to the application of unsuitable apparatus in the first instance, or to manipulative errors arising from inexperience.

Missed fires very frequently occur through the exploder being only just equal to its work, as above indicated, no allowance having been made for depreciation in the electrical appliance and cable. Missed fires sometimes arise when, after having found by experiment that a certain exploder satisfactorily fires a given make of fuze, the latter is replaced by a pattern sent out by another firm. The detonator may be sound in itself, but too weak to explode the charge.

But the causes leading more directly to the production of missed fires may be set down as follows :—

In the exploder, the electrical pressure may have fallen below the intensity necessary to overcome the resistance of the circuit.

The firing-cable may offer too great resistance, owing to: (*a*) badly-made joints, or (*b*) defective insulation, arising either from mechanical injury or absorption of moisture (Figs. 112 and 113).

In a low-tension fuze, (*a*) the bridge may be severed, as in Fig. 96 (Plate V.); (*b*) the bridge may be shunted, as in Fig. 97 (Plate V.); (*c*) there may be insufficient priming, or the latter may be damp, in which cases the bridge would incandesce without causing ignition; and (*d*) if fuzes are tested before firing, a defective bridge may then give way without firing.

In high-tension fuzes, the wires in the fuze-head (*a*) may make contact with each other, thus passing a current without decomposing the priming; (*b*) they may not make sufficiently good contact with the priming, in which case the electrical resistance is too high for an ordinary high-tension exploder.

In either variety, if a charge be left over night in a wet hole, the insulation of the fuze-wires may be destroyed. Consequently none but guttapercha-covered wires should be placed in wet holes, unless the shot is to be fired immediately after having been stemmed.

Accidents of manipulation, in tamping, and connecting up, may result in missed shots, thus :—

Whilst tamping, (*a*) the insulation of the fuze-wires may be abraded and short-circuited. On testing such a circuit *in situ*, by means of, say, a Holden firing-apparatus,* or rack-bar exploder,† the indicator would show continuity, and lead one to suppose that the fuze was in good order.

(*b*) A wire may have been inserted in the shot-hole kinked ; (see Figs. 104 and 105, Plate V.,) then, upon tamping, the strain put upon the wires by an inexperienced operator causes the weakened point to straighten out and give way inside the insulation—(as shewn in radiograph, Fig. 111).

(*c*) The wires may be partly carried into the hole by an advance stroke of the tamping-rod ; they are pulled out again forcibly, thus bringing about result (*a*) or (*b*).

(*d*) Manipulative accident (*c*) may result in the detonator being withdrawn from the cartridge, or the fuze from the detonator. (This may be entirely obviated by inserting the detonator in the cartridge, then doubling back the wires alongside the primer and making a half hitch with them round the same. The detonator-end of the primer leads into the blast-hole.)

(*e*) Splicing fuze-wires in a shot-hole. (A miner will have caps with say 36 inches wires. He has occasion to bore a 48 inches hole and so he twists pieces of old fuze-wire on to the new, lays the joints side by side, and proceeds with his stemming. The fireman comes along, applies his exploder, and "wonders why it won't 'go off'" !)

In connecting the fuze and the exploder—(*a*) the joints between the fuze and the firing-line may be dirty, or covered with tallow grease. (They should be rubbed bright between thumb and finger, with a pinch of coal or shale-dust, before splicing.)

(*b*) The manner of jointing may be mechanically but not electrically good. Fig. 106, illustrates a bad electrical joint.

(*c*) The joints, though properly made, may have been inadvertently brought into contact with each other, whilst reeling off cable.

(*d*) The firing-line may have been kinked and afterwards forcibly straightened out, thus breaking a wire. Fig. 110 shows a piece of cable

* *Trans. Inst. M.E.*, vol. xvi., page 163. † *Ibid.*, page 130.

actually served in this way by the fireman in charge of it. To all outward appearance the cable is quite sound, but on passing behind a fluorescent screen the shadow indicating a severed wire is seen through the insulation, as shown by the radiograph (Fig. 111).

(*e*) The exploder-ends of the firing-line may require cleaning; as may also the binding terminals or contact-studs on the exploder itself. (They should be cleaned daily with emery-cloth.)

The Dangers of Electric Blasting with High Explosives.—In the development of new industries and new methods, one almost invariable concomitant is the appearance of new dangers. Just as the early use of nitroglycerine resulted in many cases of unexpected fatal accident, so has the growth in the practice of blasting in collieries with other detonative explosives tended to swell the "miscellaneous accidents" columns of the reports of H.M. inspectors of mines.

The unfortunate point, in the case of detonator-accidents, is that nearly every reported instance is directly traceable to sheer want of thought either on the part of the injurer or the injured. A few examples may perhaps serve to prevent similar accidents, though no doubt a goodly number will still prefer to be "once bitten" ere they become "twice shy."

A much too frequent source of accident is that of playing with detonator-caps. A shot-firer is curious to learn something about the interior of an electric cap. He pares off the waterproof luting, and succeeds in forcibly withdrawing the fuze. (This in itself is a most dangerous proceeding, and should never be performed without taking special precaution against accident.) The shot-firer, however, must needs carry his investigations so far as "that stuff in the end of the tube," and he thereupon proceeds to poke out the fulminate with the office pen. Result: Loss of one eye and three fingers, not to mention the application to various parts of his body of a quite unnecessary amount of copper armour for a civil subject to wear in times of peace.

Take another case, that occurred at a colliery where electrical firing had just been introduced. Several firemen had turned into an underground cabin to write their reports. One was testing caps with a dry-cell and galvanometer, which latter, be it noted, had three terminals; one common, and the other two attached respectively to low and high-resistance wire coils. A certain cap, just tested, gave no deflexion of the galvanometer-needle. An onlooker essayed to repeat

the test. He did not understand detonators, but he thought he did. Everyone has met the "practical man:" the man who, if he be a mechanic, will "set his back up" against the introduction of time and labour-saving machinery; and if he be a miner will look with considerable disdain on all knowledge that has not been hewn with a pick, and driven into the chambers of the brain by falling roof. This "practical man" then held the detonator in one hand ("why bother about putting a bad cap under cover?") and calmly applied its wire extremities to the wrong terminals of the testing apparatus. Again, painless amputation of two fingers was the penalty of foolishness.

Another man tested a detonator-fuze with a low-resistance galvanometer and a firing-cell supposed to have run down, because it failed to fire through 300 feet or so of cable. He, too, looked upon the iron testing-box or pipe as a kind of appliance for the use of novices, but Nemesis arrived in the shape of a fuze with a weak bridge. Result: piece of copper in the eye.

Then there are those much more serious mishaps in which a charge of explosive plays a part. As, for example, that which occurred in a stone-drift, branching at right angles off a main-haulage road. In the heading-end, distant perhaps 80 or 100 feet, a deputy joined the fuze-wires to his firing-line and proceeded to pay out cable towards the main road, whilst the workmen were engaged in removing their tools from the face. On arrival at the junction, the portion of the firing-line still in hand was passed over a set of bare signal wires. In this act, either the two free ends of the cable or possibly a free end of one and a bare place in the other completed the circuit through the signalling-battery. The charges in the drift exploded and a human soul plunged again into the inane.

A somewhat analogous accident was that caused by a shot-firer who joined his line to a detonator-fuze on the coal-face and requested his mate to hold the wires apart, so that, in paying off cable, no short-circuit would be produced at the joints through an inadvertent pull. Having carried the line to a safe position he fired the shot, half killing the man whom he had forgotten to warn at the other end.

Other detonator accidents of more or less common occurrence arise through workmen stemming detonating-charges too forcibly, or pulling miss-fire detonator-wires out of stemmed holes. Serious accidents have also resulted from workmen having driven pick-points into detonators, whilst in the act of cutting down coal containing a charge that has missed fire.

A word or two may be said concerning reputed hang-fires of electric detonator-fuzes. The writer has produced the effect of delayed ignition artificially, but as yet he has no conclusive evidence of this phenomenon having occurred in actual blasting-operations.

The following records may, however, prove useful for reference :—On the authority of Mr. Harold Bonser,*

Two shot-holes were charged with roburite, and the chargeman, as he thought, fired them simultaneously. He detached the cable, removed the magneto-electric exploder, and placed the handle in his pocket. His assistant and another workman then went to examine the place, and to ascertain if the shots had done any work. They halted on the way, about 60 feet from where the shots had been fired ; they were about to proceed on their way when, to their amazement, one of the shots went off, and only two simple circumstances saved their lives—the halt mentioned, and the fact that it was a breaking-down shot.

Mr. J. L. Hedley,† speaking on the above case, remarked that

he had had two cases under his notice . . . . . where it was said that the detonator hung fire, and that the shot had gone off afterwards, in one case killing a man, and in the other injuring one.

Another instance of an electric detonator-fuze hanging fire is recorded by Mr. John Gerrard, in the *Transactions of the Manchester Geological Society*.‡

A correspondent in *Mining Engineering* related the following incident in the issue of November 13th, 1897 :—

. . . . . . A competent person was engaged in firing a shot in the coal by means of a battery and cable. He had got all things properly connected and he tried to fire the shot, but it would not go, so he disconnected the cable from the battery, held it in his hand for a second or two, and then put it down, when to his surprise the shot went off.||

The writer has also had reported to him a case of a breaking-in shot exploding full three seconds after removal of the exploder (an Obach dry-cell), but most people will be ready to admit that in reports of the nature here cited there is room for the exercise of a very considerable amount of philosophic doubt.

Perhaps, however, it may be as well to show how delayed ignition can occur, and for this purpose the possibilities are divided below into (1) delayed explosion with exploder in circuit, and (2) explosion with exploder removed. In class (1), any of the following causes would appear to be capable of producing the phenomenon in question. (*a*) Increase of resistance in line-wires, permitting the passage of only just sufficient electrical energy to warm the bridge. The latter has then to be kept heated for several seconds before the temperature rises

* *Trans. Inst. M.E.*, vol. ix., page 215. † *Ibid.*, page 220.

‡ 1893, vol. xxii., page 154. || Vol. i., page 420.

to the ignition-point of the priming; (*b*) fall of electrical pressure in the exploder, producing the same result as in (*a*); (*c*) badly mixed priming, burning slowly; (*d*) damp priming, burning slowly; and (*e*) insufficient priming: bridge ignites surrounding paper, which smoulders slowly towards the priming.

In class (2), causes (*c*) and (*e*) of class (1) might result in delayed ignition with the exploder detached.

A curious and, it is believed, unexplained accident occurred in the Midland mines-inspection district a short time ago. A charge in the rock roof had failed to fire, and somehow or other passed unnoticed until about a fortnight afterwards, when it is said to have exploded spontaneously and brought down the rock.

Accidental explosions of submarine mines have occurred many times between that in the harbour of Pola in the sixties, and one on the U.S.A. west coast a few weeks ago.

The following account given by Sir Frederick Abel may suggest sources of danger, if it should be found at any time that underground blasting was being carried out under conditions that might render the setting up of an induced current possible :—

> Two instances of the accidental explosion of tension-fuzes by the direct charging of overhead wires during lightning discharges occurred in 1873 at Woolwich, and a fuze connected with an overhead insulated wire at Chatham was also exploded accidentally in the same year, though whether by an induced charge or by the direct action of a lightning-discharge was not conclusively demonstrated. Subsequently an electric cable was laid out at Woolwich along the river-bank below low-water mark, and a tension-fuze was attached to one extremity, the other being buried. About 11 months afterwards, the fuze was exploded by a charge induced in the conductor during a very heavy thunderstorm.*

In concluding this series of papers, the preparation of which have occupied nearly all his leisure, and, not infrequently, disputed his proper working-hours, during the past 3 years, the writer trusts that they will be found to contain information useful alike to the historian of to-morrow, and the engineer of to-day.

It is a pleasure to record his acknowledgments to his friends Mr. de Grave and Mr. Goormaghtigh ; to the various manufacturers who have favoured him with the information which he has sought ; and not least to the secretaries of the Chesterfield Institution and The Institution of Mining Engineers, for their uniform courtesy and readiness to meet his wishes during a correspondence in connexion with these papers extending over a period of 2 years.

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* "Electricity applied to Explosive Purposes," *Practical Applications of Electricity*, 1882-83, page 131.

APPENDIX I.—Glossary of Technical Words and Expressions.

Ampère.—The practical unit of electric current strength. It is the measure of the current produced by an electro-motive force of 1 volt, through a resistance of 1 ohm.

Armature.—In these papers, the portion of a dynamo which revolves between the field-magnets. Such an armature generally consists of a mass of sheet-iron discs (tightly keyed and clamped on to a driving shaft) carrying coils of insulated wire, which serve to set up and maintain a difference of potential, and consequently a current.

Armature, Gramme-ring.—The type of armature designed by Mr. Zénobe Théophile Gramme. It usually consists of a ring (composed of iron wires) of great diameter in proportion to length. Insulated wire-coils are wound round and round the ring, the ends of all the coils being united so as to form one continuous closed circuit.

Armature, Shuttle-wound.—A type of armature originally designed by Dr. Siemens, and frequently called a Siemens armature. It has a cross section of I shape, its diameter being small in proportion to its length. The I armatures used in exploders are usually solid castings, wound longitudinally with insulated wire, to form a cylindrical armature.

Carbon, Retort.—Carbon obtained from gas retorts.

Chatterton Compound.—A cement composed of Stockholm tar, guttapercha, and colophony. It is prepared in the form of small black sticks, and used for the purpose of cementing prepared tape to an insulated joint in wire or cable.

Circuit.—A path capable of conducting electric-currents. Generally, a complete conducting path including some form of generator.

Circuit, Closed.—The converse of open circuit. A complete conducting path.

Circuit, Open.—A conducting circuit which has been broken at some point or points so as to form a path of infinite resistance, as, for example, when a switch interposed in a circuit is turned "off."

Circuit, Short.—A portion of a conducting circuit which has been bridged by a conductor of low resistance, compared with the normal path. Suppose, as an illustration, that the connexions between a firing-line and a fuze make contact with each other. When an attempt is made to fire the shot the current passes through this "short circuit," instead of through the fuze, thus producing a miss-shot due to the alternate path having a very much lower resistance.

Collodion Varnish.—A solution of gun-cotton in ether. It is exceedingly inflammable at a low temperature.

Conductivity.—The reciprocal of resistance. The relative power possessed by different substances of conducting an electric current.

Di-Electric.—Any non-conductor of electricity. The insulation surrounding a conducting wire is spoken of as the di-electric of the wire.

Dynamo, Series-wound.—A dynamo whose armature, field-windings, and external circuit are all joined end to end, *i.e.*, in series.

E.M.F.—Abbreviation for electro-motive force. The practical unit of electromotive force is the volt.

Field, Magnetic.—The space about a magnet within which a piece of iron is perceptibly acted upon. In these papers, the expression magnetic field invariably refers to the space between the poles of a magnet, within which an armature is caused to rotate.

Gramme-ring.—See Armature, Gramme-ring.

GUM TRAGACANTH.—The gum of a thorny shrub of that name grown in Crete, Asia, and Greece.

INDUCTION, SELF-.—A phenomenon of electric currents analogous to the inertia of matter. The sparks, produced at the contacts of switches when breaking a current carrying circuit, are due to the induced current momentarily set up by the sudden stoppage of current-flow.

INSULATION.—Non-conducting medium or di-electric.

MERCURY, FULMINATE OF.—The explosive compound employed in detonator- and percussion-caps. It is a yellow chemical compound having the formula $Hg_2C_2N_2O_2$, and is prepared by treating a solution of mercury in nitric acid with alcohol. This compound explodes when heated to about 360° Fahr. It also detonates by friction, by the electric spark, and by contact with concentrated sulphuric and nitric acids. According to Messrs. Liebig and Gay Lussac,* it consists of protoxide of mercury in combination with fulminic acid.

OHM.—The name given to the practical unit of electrical resistance. So called in honour of Prof. Jules Simon Ohm, who first formulated the law (Ohm's law) showing the inter-relationship between current, electro-motive force, and resistance in a circuit. It is defined as the resistance of a column of pure mercury 1 square millimetre in cross-section, and 106·3 centimetres long at a temperature of 0° Cent.

POLES.—(*a*) The terminals of an open electric circuit, at which there necessarily exists a potential difference, produced by the generator, or source of electro-motive force in the circuit. (*b*) The terminals of an open magnetic circuit; the ends of a magnetized mass of steel or iron. (*c*) The ends in general of any body or mass which show electric or magnetic properties more developed than those of the central sections of the body.

RETORT CARBON.—See Carbon, Retort.

SELF-INDUCTION.—See Induction, Self-

SERIES-WOUND DYNAMO.—See Dynamo, Series-wound.

SHORT CIRCUIT.—See Circuit, Short.

VOLT.—The practical unit of electro-motive force and potential, so named after Volta, the discoverer of means for producing a steady current. The volt is taken as the potential difference required to send a steady current of 1 ampère through a resistance of 1 ohm.

VOLTMETER, VOLTMETER-DEFLECTION.—A voltmeter is an instrument for determining the potential difference between any two points of an electrical circuit. When such an instrument is joined up to a current-carrying circuit the deflexion of a needle or pointer indicates on a scale or dial the value in volts, or fractions of a volt, as the case may be, of the electro-motive force producing the current.

VOLTMETER RESISTANCE.—In order that a voltmeter may be actuated by an exceedingly small fraction of the total current, its coil is wound with a great length of very fine wire, that is, its circuit is of very high resistance. The voltmeter resistance is the resistance of the fine wire-coils, and is frequently marked on the back, or on the dial of high-class instruments.

APPENDIX II.—RULES AS TO SHOT-FIRING AND EXPLOSIVES.

It is hoped that the following rules may prove useful for reference. Many are already in daily operation at a great number of collieries.

* *Annales de Chimie et de Physique*, vols. xxiv. and xxv.

Some are due to the late Mr. W. J. Greener of Pemberton colliery; others are in force more or less at every mine practising electric blasting; whilst a few—Rules 9, 10, 11, 13, 15, for example—are not, it is thought, quite so extensively adopted as they might be. The last-mentioned rule (15) is included on the suggestion of Mr. W. H. Hepplewhite.

1. Shots shall be fired in such mines, in such places, at such times, and with such explosives only as are from time to time authorized by the manager.

2. All shots shall be (charged and) fired electrically, by persons duly authorized in writing by the manager.

3. Persons authorized to fire shots shall make themselves thoroughly acquainted with the General and Special Rules relating thereto, and strictly carry them out.

4. Cartridges shall be carefully pushed into the hole with a wooden stemmer, so that they touch each other, but they shall not be broken. Care shall be taken not to damage the detonator, which shall be buried overhead in the cartridge, and the fuse wires doubled back along the same.

5. The shot-firer shall have absolute control over the charging of any shots which he may deem irregular and unworkmanlike. No shots shall be charged where a hole has been drilled into the solid, and no explosive shall be forced into a hole of insufficient size. Should the explosive become fast before reaching the bottom of the hole, the hole shall be stemmed up, and a fresh one drilled at a distance of not less than 8 inches from the first.

6. No hole shall be charged in coal unless the holing exceeds 3 feet in depth, and unless the hole is of such depth as will admit 10 inches of ramming being placed against the charge. [This rule to be amended or omitted according to local character of seam.]

7. Charges shall be tamped lightly at first with moist clay, or other non-gritty, non-inflammable material. In no case shall coal or coal-dust be used for tamping.

8. Wooden rammers or stemmers, of such thickness as to just slide freely in the drill-hole, only shall be used in charging or stemming any hole.

9. Detonators shall have unjointed wires, of sufficient length for the holes in which they are to be used. The joints between the detonator wires and the firing line shall be free from candle grease or dirt, and be as dry as practicable.

10. The shot-firing cable shall be of such length as to place the operator beyond reach of danger from flying *débris*.

11. The shot-firer shall examine his place of refuge and assure himself that he is adequately protected from danger before firing a charge.

12. The shot-firer shall, after firing a shot, examine the brattice, doors and roof, turn over the material blown down, and satisfy himself that everything is safe.

13. A missed-shot shall not be drawn, or otherwise interfered with, nor shall it be approached until after the expiration of 15 minutes from the time of disconnecting the exploder. The charge shall then be joined to a newly tested cable and exploder, and tried again. If it still fails to fire, a fresh hole shall be drilled at a distance of not less than 8 inches from the missed-shot. The new hole shall be drilled at such an angle that it cannot possibly break into the old hole.

14. Coal or stone containing a missed-shot shall in no case be got down with pick or wedge, but must be blown down by another shot.

15. When a missed-shot has occurred, the same shift of men shall put in the new charge, and the shot-firer shall be present whilst they are so engaged.

16. The shot-firer shall, before firing a new hole, attach the missed-shot wires

also to the cable, by means of a piece of wire or cord, to aid in recovering the missed shot. Immediately after firing he shall search the coal, and until he finds the detonator, or is satisfied that it has been exploded by the second shot, shall allow no person to interfere with the coal or stone.

17. Search for explosives in the material blown down shall be made with the hands only, and with the greatest care.

18. Should a second shot not dislodge the missed-charge further holes must be drilled and fired until this is effected.

19. No tools shall be used for the purpose of breaking up a block of mineral supposed to contain an unexploded charge. The block containing a missed-charge shall, when recovered, be securely packed in the goaf.

20. Deputies shall see that mineral containing, or supposed to contain, an unexploded charge is not sent up the shaft.

21. Explosives shall not be used for breaking in "fast ends."

22. Shot-holes shall be of just such sufficient diameter to pass the cartridges in use, and shall be drilled at such an angle that they do not directly face the air-current.

23. Detonators shall be kept in a metal case, to themselves, absolutely.

24. Detonators shall not be "tested" by running a tram over them, or otherwise attempting to destroy the cap.

25. No detonator shall be placed upon the floor, but shall remain in the box provided for that purpose until immediately required for use.

Corrigenda.—*Trans. Inst. M.E.*, vol. xv., page 201, sentence in sixth line from bottom of page should read:—"He was of opinion that experiments with the improved blasting-powders ignited in the manner proposed should be made at the Woolwich testing-station, since the working of the Explosives in Coal-mines Order had the effect of putting a stop to private research."

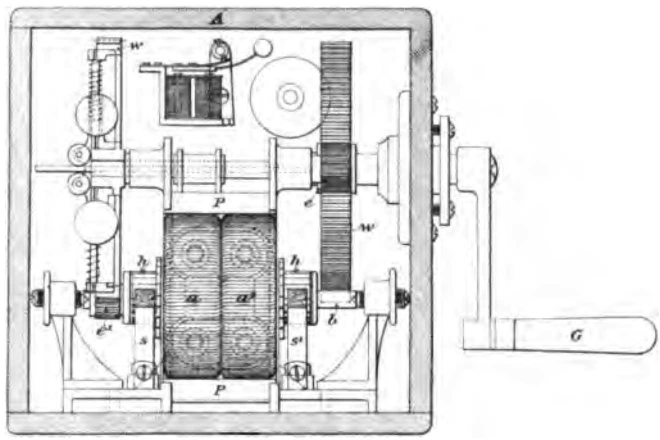

Fig. 68.

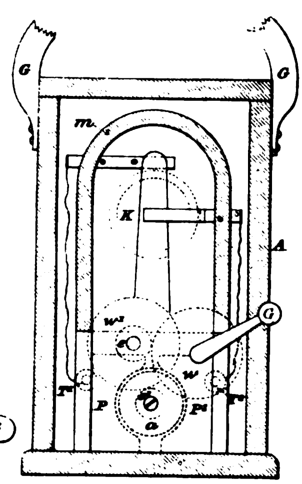

Fig. 71.

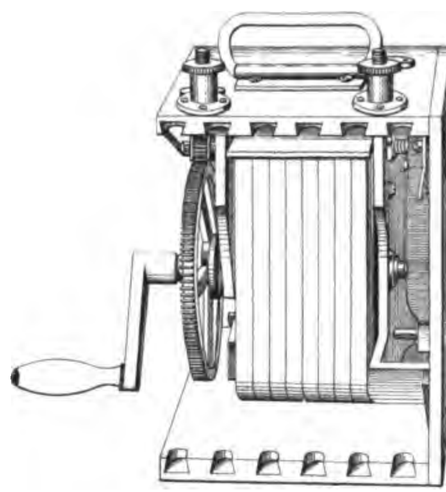

Fig. 72.

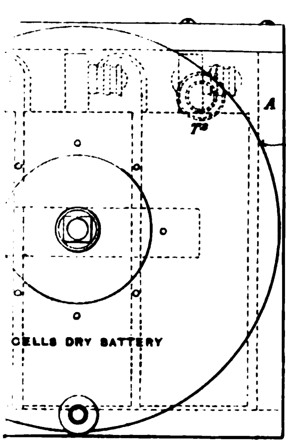

Fig. 77.

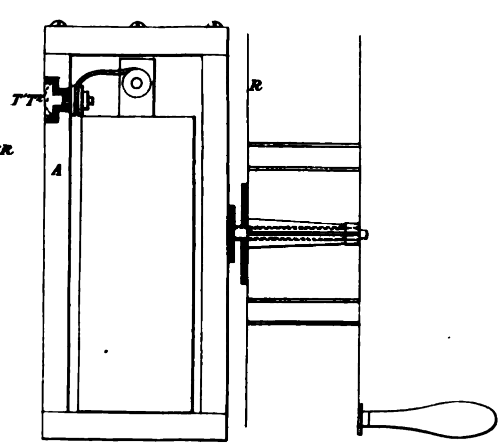

Fig. 78.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, DECEMBER 10TH, 1898.

MR. WILLIAM ARMSTRONG, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on November 26th and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. THOMAS WILLIAM TURNER ATHERTON, Chief Mining Engineer, Mijnbouw Maatschappij, Bwool, Celebes.

Mr. HARRY FOSTER BAIN, Assistant State Geologist of Iowa, Des Moines, Iowa, United States of America.

Mr. THEODORE BREIDENBACH, Mine Manager, Mikado, Rat Portage, Canada.

Mr. JAMES CARROLL, Manager of Brilliant and St. George Gold-mine, Charters Towers, Queensland, Australia.

Mr. WILLIAM CLARK, Colliery Manager, Cranbury Lodge, Park Lane, Wigan.

Mr. A. J. COLQUHOUN, Mining Engineer and Assayer, Vancouver, British Columbia.

Mr. ALFRED S. EDGECOMBE, Mining Engineer and Metallurgist, Rossland, British Columbia.

Mr. JOHN JAMES CONSTANT FERNAU, Mining and Civil Engineer, Nenthead House, by Alston, Cumberland.

Mr. HENRY J. A. HERRMANN, Mechanical Engineer, Cranleigh, Woodford Green, London.

Mr. THOMAS JAFFREY, Engineer and Mill Manager, John Bull Gold-mine, Limited, Ravenswood, Queensland, Australia.

Mr. G. F. MONCKTON, Mining Engineer and Assayer, Lytton, British Columbia.

Mr. GEORGE ARTHUR PINGSTONE, Analytical and Consulting Chemist, P.O. Box 212, Bulawayo, Rhodesia, South Africa.

Mr. JOHN ARCHIBALD PRINGLE, Mining Engineer, Blakeney, Newnham, Gloucestershire.

Mr. JOHN SATTERTHWAITE, Mining Engineer, Garbham Mines (Vizianagram Mining Company, Limited), Chipurnpalle, Vizagapatam District, India.

Mr. ALFRED GODDEN SMITH, Mining Engineer and Manager, Golden Valley Ochre and Oxide Company, Wick, Bristol.

Mr. JOHN SOUTHERN, Colliery Manager, Heworth Colliery, Felling, R.S.O., Co. Durham.

Mr. T. TREVAILLÉ-WILLIAMS, Mining Engineer, P.O. Box 271, Johannesburg, South African Republic.

Mr. WALTER FRANCIS AINSLIE WADHAM, Civil and Mining Engineer, Millwood, Dalton-in-Furness.

Mr. JOHANNES WESTPHAL, Bergrefcrendar, Eichenallee 23, Westend, near Berlin.

ASSOCIATE MEMBERS—

Mr. A. A. BLOW, The Sheba Gold Mining Company, Limited, Eureka City, Barberton, South African Republic.

Mr. A. R. BOYLE, Melbourne and Metropolitan Board of Works, Rialto, 501, Collins Street, Melbourne, Australia.

Mr. CHARLES J. COLLOPY, P.O. Box 1212, Johannesburg, South African Republic.

Mr. W. J. R. COWELL, The Victoria Metallurgical Works Company, Limited, Victoria, British Columbia.

Mr. WILLIAM J. GILBERT, Monarch Gold-mining Company, Gullewa, *via* Yalgoo, Murchison, Western Australia.

Mr. WILLIAM HAMILTON, JUN., The William Hamilton Manufacturing Company, Limited, Peterborough, Ontario, Canada.

Mr. ALBERT J. HILL, New Westminster, British Columbia.

Mr. THOMAS SNOWBALL INNES, Crown Chambers, Side, Newcastle-upon-Tyne.

Mr. JOSHUA JEFFRIES, Greta Collieries, Greta, New South Wales.

Mr. G. BENTLEY POORE, P.O. Box 149, Johannesburg, South African Republic.

Mr. JOHN ROSEN, 28, St. Charles Square, North Kensington, London, W.

ASSOCIATES—

Mr. THOMAS DANSKIN, Deputy-overman, Springwell Colliery, Gateshead-upon-Tyne.

Mr. WILLIAM ROCHESTER, JUN., Overman, Emma Colliery, Ryton-upon-Tyne.

STUDENTS—

Mr. CHARLES ARTHUR CROFTON, Mining Student, Peases' West Institute, Crook, Co. Durham.

Mr. WILLIAM DENHAM HARBIT, Mining Apprentice, 32, High Street, Wallsend-upon-Tyne.

Mr. RICHARD NASH PEARSON, Mining Student, Tamworth Colliery, Alvecote, Tamworth, Warwickshire.

The following paper by Mr. H. Foster Bain, on "The Western Interior Coal-field of America," was read:—

THE WESTERN INTERIOR COAL-FIELD OF AMERICA.

By H. FOSTER BAIN, Assistant State Geologist of Iowa.

Classification of American Coal-fields.

The coal-fields of the United States of America underlie an area variously estimated at from 200,000 to 300,000 square miles. The extent of many of these fields is yet unknown, and detailed knowledge of the stratigraphy of almost all of them is lacking. Their location and general outline, so far as known, are laid down upon the accompanying map (Fig. 1, Plate VI.). The data for this map were collected for, and first published in, the Eleventh Census.* The outlines of the various fields as far west as the Missouri river are accurate within the limits of the map; but west of that the spots coloured indicate points at which coal is known to occur, more often than they give the full extent of the fields.

In a general way it may be said that the eastern fields are in the Carboniferous, while the western belong to the Mesozoic system, but this statement has exceptions to be noted later. For statistical purposes, the coal-fields have been classified by the U.S. Geological Survey into the following groups, which, as will be readily seen, agree in most instances with geographical and geological units. The production of each field in 1897 is given below :—

	Tons of 2,000 lbs.
Anthracite	52,500,839
Triassic	116,950
Appalachian	97,291,187
Northern	223,592
Central	26,414,127
Western Interior	13,164,059
Rocky Mountains, etc.	8,854,182
Pacific Coast	1,639,779
Total	200,204,715

The anthracite-production includes small amounts from Colorado and New Mexico, from coal-fields not marked on the map. The major production is, of course, derived from the Pennsylvania coal-field. The New England beds are not now producing. As will be noted, the largest

* *Eleventh Census of the U.S.A.*, vol. i., *Mineral Industries*.

amount of coal mined comes from the Appalachian coal-field. It was the southern portion of this field which was described recently by Mr. Jeremiah Head.* The Central coal-field stands second in production among the bituminous fields, the Western Interior is the third. It is the latter coal-field which it is the especial province of this paper to describe. The production of this coal-field for 1897 is given (by states) below. The total 13,164,059 short tons, constituted 8·9 per cent. of the whole production of the United States for the year, and was an increase of 29·1 per cent. over the output for the preceding year.

States.	Tons.	Value.	
Iowa	4,611,865	$5,991,735	£1,248,278
Missouri	2,665,626	4,298,994	895,624
Nebraska	645	3,000	625
Kansas	3,054,012	2,235,631	465,756
Arkansas	856,190	194,400	40,500
Indian Territory ...	1,336,380	1,286,692	268,061
Texas	639,341	150,000	31,250
Totals	13,164,059	$14,160,452	£2,950,094

Location and Extent of the Western Interior Coal-field.

This coal-field stretches in a long irregular belt for a distance of approximately 900 miles north and south, and has a maximum width of 300 miles east and west. As much of it has not been accurately surveyed, its exact area cannot be stated. It includes portions of Iowa, Missouri, Nebraska, Kansas, Arkansas, Indian Territory and Texas. The active mining operations are largely confined to Iowa, Missouri, Kansas, Arkansas and Indian Territory. The estimated area in each state is as follows :—

	Square Miles.
Iowa	20,000
Missouri	23,000
Nebraska	3,200
Kansas	17,000
Arkansas	14,700
Indian Territory	12,000
Texas	6,000
Total	95,900

These estimates include both barren and productive beds. The really valuable ground would of course be much smaller. For example, Dr. J. C. Branner †in 1892 estimated the known coal-bearing territory of Arkansas at 1,620 square miles. This has since been increased of course by detailed prospecting, and there are still extensive reserves of unproven value. In Iowa, about one-half of the coal-measures are

* *Trans. Inst. M.E.*, vol. xiii., page 177.

† *U.S.A. Geological Survey, Mineral Resources*, 1892, page 304.

underlain by what are called the productive measures. Within the area of the latter, diamond-drill work shows variable amounts of mercantile coal. In prospecting one field of about 5,000 acres, approximately 12 per cent. was found to include workable coal. In Polk county, with a total estimated production up to date of 10,000,000 (short tons of 2,000 pounds) tons, but 3 per cent. of the total area of 375,200 acres has been prospected and less than 0·6 per cent. has been worked out.* In Missouri, Mr. Winslow suggests† 10 per cent. as a possible measure of the proportion of field which will produce coal. Hardly sufficient data exist for making a trustworthy estimate for the whole field, but it may at least be stated that not only is the Western Interior field the largest known coal-field in the United States, but so far there is no reason to doubt that it will yield approximately as much coal as any.

General Stratigraphy.

The Western Interior coal-field occupies a portion of the western half of the Mississippi valley. In its major extent the region is a vast level plain sloping very gently from the Rocky Mountains on the west to the Mississippi on the east. This plain is diversified by certain areas of uplift which jut out into the coal-field from the east. To the north-east is the area of pre-Carboniferous rocks of the Lake Superior region. This doubtless in Carboniferous times, as now, formed an elevated land-mass which then drained south-west into the sea. Between the main mass and a long arm from this area stretching off to the south-west a bay was formed, and in the latter is the present northern limit of the coal-field. South from the Wisconsin area, there was probably a ridge of land dividing, at least partially, the basins in which were accumulating the beds now making up the coal-measures of the Western Interior and the Central coal-fields. At present, the erosion of the river Mississippi and its tributaries is the main factor in the separation of the fields. There is not wanting, however, certain evidence in the beds themselves to indicate that the dividing-line marks as well an original shore-line. It seems accordingly that the Central and Western Interior fields, if not originally separate, were at least connected only by occasional lagoons and arms of the sea.

To the south-east, it will be noted that the western border of the field shows a great embayment. This is due to the Ozark uplift,

* "Geology of Polk County," by Mr. H. F. Bain, *Iowa Geological Survey*, 1897, vol. vii., page 359.

† *Missouri Geological Survey, Preliminary Report on Coal*, 1891, page 49.

around the northern, western and south-western flanks of which the Coal-measures sweep. It has been supposed that the Ozark rocks represent a pre-Carboniferous land-mass and that the Coal-measures were deposited upon its slopes in much the same position that they now occupy. This view has been recently challenged by Messrs. Keyes and Marbut, who, arguing from the physiography of the region and the presence of Coal-measures on the crest of the mountains, maintain that the uplift is very recent: Mesozoic or even Tertiary in age. If the latter view be accepted, it follows that the south-eastern border line of the field is due to erosion and the retreat of the cliffs—a view quite in harmony with field appearances.

Immediately south of this embayment will be noticed a long arm of Coal-measures reaching out to the east and occupying the valley of the Arkansas river between the Ozark and the Ouachita uplifts. The Ouachita mountains, which form the southern or extreme south-eastern border of the field, are composed of Palæozoic strata, mainly of pre-Carboniferous age. The Coal-measures have been caught up in this folding which is post-Carboniferous, and in Arkansas and Indian Territory, they show its influence; but the core of the mountains consists of earlier beds.

To the extreme south-west is the bituminous coal-field of Texas, which is usually considered to be the prolongation of the main field. There are, however, some reasons for believing that it has had a separate history. The detached areas indicated on the map east of the main Texas field, as well as the area in Central Kansas, and the smaller area in south-eastern South Dakota mark lignite-fields belonging to the Mesozoic. The western border of the coal-field is everywhere formed by the overlapping edges of later strata. In a general way, the dip of the whole series is to the west, though there are important exceptions, and the beds after passing under the great plains are brought to the surface again along the eastern edge of the Rocky Mountains. They are not, however, coal-bearing in the latter region, nor, so far as we now know, far under cover of the latter beds. In general, the workable areas are the areas of outcrop of the productive series only.

In discussing in greater detail the stratigraphy of the region, it will be convenient, for many reasons, to consider separately the areas north and south of the embayment made by the Ozark rocks. The northern portion may be called the Iowa-Missouri coal-field, though the term is occasionally made to cover the entire field, and the southern may be known as the Arkansas-Indian Territory.

THE IOWA-MISSOURI COAL-FIELD.

The first geologist who visited and reported upon this field was Dr. David Dale Owen, who, in his report issued in 1852,* made known the general outline of the field and many of the essential facts of its stratigraphy. Since then it has been studied by Messrs. Swallow, Broadhead, Marcou, Geinitz, Worthen, St. John, White, Calvin, Keyes, Winslow, Haworth, and many others.

The formation consists of two main portions, an upper or barren, and a lower or productive series. To this upper division has recently been given the name Missourian, while the term Des Moines has been applied to the lower. The Missourian series consists of a number of distinct formations beginning with the Bethany limestone, and extending up to, and including the Cottonwood limestone. It is made up in Iowa and Missouri mainly of thin limestones, with intercalated argillaceous aud calcareous shales, and contains very little sandstone with only thin seams of coal. The Nodaway bed, mined in southwestern Iowa and the adjacent portion of Missouri, is probably the most important. It is from 15 to 22 inches thick, and has a known north-and-south extent of something over 40 miles. It is worked along the outcrop mainly by drifts, and supplies the local market with household coal. The mines are small, poorly equipped, and usually run only in the winter season. It is not improbable that the coal mined in Nebraska comes from the same bed, as it occupies the same general position in the series on the western side of the syncline, that the Iowa mines hold to the east. In these states, the Missourian formation can never be expected to become a large producer of coal, and in the future, as now, the main supply must come from the lower beds. In Kansas, the Missourian includes certain shaly members, individually reaching a thickness of 600 feet and carrying thin seams of coal, which, from their position, well towards the western limit of the field, have considerable importance. Here, as elsewhere, however, the great bulk of the coal comes from the lower beds.

The Des Moines series includes three formations, which are unequally developed. The uppermost division is formed by the Pleasanton shales, which in Kansas attain a thickness of 200 feet. To the north, they thin until in central Iowa the shales are hardly to be separated from the next lower member. Below the Pleasanton comes the middle member of the

* *Report of a Geological Survey of Wisconsin, Iowa and Minnesota*, 638 pages, Philadelphia, 1852.

series. It passes under various names in different parts of the field. In Kansas, it consists of two well-marked limestones, known as the Oswego and Pawnee, with an intercalated shale-bed. In south-western Missouri, the latter becomes unimportant, and the limestones come together so as to form a single escarpment. This is known as the Henrietta, and is well displayed near Hume in Bates county. The great bulk of the coal is mined in the area between this escarpment and the outer edge of the Coal-measures. In northern Missouri, the Henrietta limestone breaks up into a number of thin beds separated by shales and carrying important but thin coal-seams. This phase of the formation has been called the Appanoose. In Schuyler, Putnam and Adair counties, Missouri, and Appanoose and Wayne counties, Iowa, the formation is very regular; it carries an important seam of coal known variously as the Mystic, Centreville, Mendota or Stahl coal. This bed has an areal extent of at least 1,500 square miles, and an average workable thickness of about 2½ feet. It thins very gradually, with a dip to the west, and passes below the later beds. The main openings are along the outcrops, where drifts are, of course, largely employed. There are no important mines much more than 15 miles back from the edge, where the coal is found at a depth of about 250 feet. A section of this bed has already been given, and the general methods employed in mining it have been mentioned.*

North of the region of outcrop of the Appanoose formation there are equivalent beds, though exactly the same sequence does not prevail. The thin coal-seams found are only mined for local consumption, and do not influence the general market.

Below the middle member is the formation which Dr. Haworth has called the Cherokee shale,† from the county in Kansas, where it supports so large a mining industry. It crops out over a crescent-shaped area following the outer line of outcrop of the Coal-measures from Kansas to north-central Iowa. In general, the beds throughout the area dip toward the centre of the circle, which would be formed by the prolongation of the horns of the crescent. The general dip is, however, so slight that mining operations are wholly uninfluenced by it, and except for occasional local dips the beds are apparently horizontal The region is an open plain, and the surface-inequalities are only those due to river-erosion. The country is well supplied with railways, and has an important population.

The Cherokee shales vary in thickness between 200 to 600 feet along the outcrop of the next higher formation, and thin to nothing at their

* *Trans. Inst. M.E.*, 1897, vol. xiii., page 478.

† *Univ. Geological Survey, Kansas*, vol. i., pages 150-157.

own outcrop. The formation is made up largely of shale and sandstone, and carries numerous important coal-beds. The individual strata vary in thickness and character from point to point, so that it is impossible to construct a general section of more than local value. In the south-west, especially in south-eastern Kansas and the adjacent portions of Missouri, the beds are apparently more regular than elsewhere, and the irregularities found farther north serve to mark this as an exceptional portion of the field.

In Iowa and much of Missouri, the coal-beds have been cut out in a variety of ways. In the first place, the beds are practically horizontal while the streams have cut 200 to 250 feet below the upland. As a result, a considerable amount of coal has been cut out. Since, however, these deep valleys afford ready means of tracing and opening the coal-seams, they are probably more advantageous than detrimental. There is, however, another series of valleys which cause a good deal of loss and have no corresponding value. The region as far south as the Missouri river is covered by the till or boulder clay laid down by glacial agencies. In the period immediately preceding the advent of the glaciers, the region stood high and was much cut up by the streams The valleys cut at this time being later on filled by glacial *débris*, are now entirely concealed and often seriously affect mining. In one case, a drift had to be driven in soft water-bearing material more than 300 feet, in crossing such a valley. Fortunately the present streams seem to follow very largely the courses of their older prototypes, so that with a little care in selecting ground these buried valleys may be usually avoided.

The most serious limitation to the workable coal is the fact that the beds of the northern portion of the field do not maintain a constant thickness. They thicken and thin rapidly, varying from nothing to 7 feet in a few feet. The usual variation is from about 18 inches to 6 feet. The thicker, workable beds lie in basins or troughs of very irregular outline. The coal varies a little in elevation, differences of 20 to 30 feet being common, and as much as 60 feet of local dip being observed in a single mine. Usually the coal thins to the rise, and it seems that irregularities are a result of the original irregularities of the bottom. In the case of the lower coal worked near What Cheer in Keokuk, Iowa, the inequalities can be referred to the irregularities of the old erosion-surface of the St. Louis limestone upon which the Coal-measures rest unconformably.* This condition is paralleled by the outlying pockets of very thick coal found in Missouri along the borders of the field,

* *Iowa Geological Survey*, 1894, vol. iv., pages 255-311.

and described by Mr. Arthur Winslow.* In some of these pockets, coal 70 feet thick has been found, but its extent is very limited. The coal occurs in narrow channels eroded in the earlier rocks. In one instance, such a channel is known to be 100 feet wide, and has been followed for 500 feet. These pockets have attracted much attention, but are really of small value. Their exploitation has entailed the loss of considerable sums of money.

In the Iowa mines no such thick deposits have been found, but corresponding irregularities in the beds worked are common throughout the field. The beds thicken and thin so rapidly that it has so far proved impracticable to construct a general section of the formation, or to make any extended correlations between the coal-beds. The following records of certain diamond drill-holes, all reaching the same coal and being within 2 miles of each other, will illustrate these variations :—

No. of Bore-hole.		Elevation of Top of Hole. Feet.		Elevation of Coal or Bottom of Hole. Feet.		Thickness of Coal. Ft.	In.
1	...	849·8	...	682·3	...	4	6
2	...	888·0	...	541·0	...	0	0
3	...	881·0	...	673·0	...	7	0
4	...	951·0	...	639·0	...	0	0
5	...	949·8	...	644·7	...	0	6
6	...	892·9	...	701·4	...	3	6
7	...	874·5	...	720·8	...	1	0
8	...	897·8	...	701·3	...	3	0
9	...	945·8	...	719·5	...	0	6
10	...	939·0	...	708·5	...	3	11
11	...	902·7	...	655·7	...	6	2
12	...	885·3	...	623·3	...	0	0
13	...	881·8	...	613·8	...	0	0
14	...	912·3	...	634·3	...	0	0
15	...	874·9	...	663·9	...	7	3
16	...	869·0	...	686·7	...	0	8
17	...	879·4	...	671·4	...	4	8

As may readily be supposed, this uncertain character of the coal-beds influences largely the methods and cost of prospecting and opening. The very general covering of boulder-clay of a thickness varying from 50 to 250 feet also adds to the difficulty of locating a mine. The prospecting is nearly all done by drilling. The extent of a given coal-basin is so uncertain that monkey-shafts are very little used. In order to locate the coal with sufficient accuracy to warrant opening, it is sometimes necessary to put down ten drill-holes on a single square mile. When the depth is less than 100 feet, and there has been work enough in the region to make the strata pretty wellknown, the common churn or percussion-drill, driven by horse or steam-power, is used. This work is cheap, the cost being from 25 to 75 cents (1s. to 3s.) per foot, but the results are

* *Missouri Geological Survey, Preliminary Report on Coal*, 1891, pages 167-172.

uncertain and the extended use of this type of drill cannot be recommended. The best work, and all the large contracts, are done with the diamond core-drill. As carried on in this field, this work probably costs about $1 (4s.) a foot for average depths and conditions. One extended job has recently been finished at a cost of 72 cents (3s.) per foot, but the work was done there with exceptional economy. The total cost of prospecting depends of course on the area and the difficulties. In general it costs from $5,000 to $10,000 (£1,000 to £2,000) to locate enough coal for a big shipping-mine. One company leased 5,000 acres, put down 20 diamond drill-holes, and located about 600 acres of coal for $7,000 (£1,400).

A majority of the mines are opened by shafts. These are oblong in cross-section, usually having two compartments, each used for hoisting, and are ordinarily 7 by 14 feet in the clear. They are timbered with 4 to 12 inches timbers, and are frequently sunk by contract. An ordinary shaft costs about $12 (£2 10s.) per foot for sinking, plus the timber, etc.

FIG. 3.—PEKAY COAL-MINE, MAHASKA COUNTY, IOWA.

The inequalities of the thickness of the beds limits the amount of coal which may be advantageously mined from one shaft. The fact that none of the mines are deep, the deepest mine now operating in Iowa reaching about 250 feet, makes it cheaper usually to sink a new shaft rather than drive through thin coal and make a long underground haul. These natural conditions, coupled with the high rate of interest and the

desire for quick returns also influence the methods of working. The mines are frequently capitalized inadequately, and cheap installations with smaller returns are the rule. The life of an individual mine is short, 10 to 20 years, and after the immediately adjacent territory is worked out, the plant is moved to a new site.

Comparatively little of the area is adapted to longwall and various forms of room-and-pillar work are adopted. A very common form is that shown in Fig. 2 (Plate VI.), where the cross-entries are driven 350 feet apart, and the rooms after being driven in 14 feet are widened to 30 feet. They are then driven until they meet the rooms from the next cross-entry. The pillars between adjacent rooms are then mined back, and the work is closed up. All the work is advancing, so that the last coal mined has a long haul through old workings. Sometimes the rooms are worked in panels, but usually not. Ventilation is accomplished in most instances by fans. There are no explosive or dangerous gases, and under normal conditions there is very little water to contend with. Tramming is done by mule-power in the smaller mines, and on the cross-entries of the larger ones. For the main hauls, tail-ropes and continuous ropes are usually used, though electric motors are occasionally put in. The tail-rope system seems to be the favourite. The mine-cars are ordinary wooden boxes with iron frames and loose wheels. They hold, as variously built and loaded, from 1,200 to 2,200 pounds. The small country-mines raise the coal by horsepower, but steam-hoists are almost universal.

The coal is nowhere cleaned, except by a certain amount of hand-picking in the mine. It is sized by being allowed to fall over fixed grizzleys with an occasional trommel-screen for the smaller sizes. It is usually loaded directly into cars which stand on track-scales, the coal being weighed as it is loaded. When box-cars are being loaded, the coal is thrown to the ends of the car by an ingenious machine known as a box-car loader, which is driven by an independent engine set on the opposite side of the car from the coal-shoot. This engine is attached, by means of an eccentric or crank-shaft, to a pivoted beam working in a horizontal plane. The free end of the beam is armed with a shoe against which the stream of coal falls. As the beam is given a rapid vibratory motion, it knocks the falling lumps of coal first to one end, then the other of the car.

The shaft-house and all top-works are usually built of wood, though in some cases brick boiler-houses or corrugated iron sheeting is used. There is, of course, danger of fire with wooden structures and several

disasters have resulted from it. A separate escape-shaft is, however, required by law, so that the loss of life has fortunately never been great.

The big coal-mining camps of Iowa are situated in a line across the state following the Des Moines river. Fort Dodge, Boone, Des Moines, Oskaloosa and Ottumwa, are found in succession following down the valley, and each mark the crossing of the river by an important east-and-west railway. From Ottumwa westward, along the line of the Chicago-Burlington-Quincy railway, there has always been considerable mining. The Cleveland mines of the Whitebreast Fuel Company, in Lucas county, were long the largest in the state, and at present the Heitman mines of the Wapello Fuel Company, in Monroe county, are the most important west of the Des Moines valley. South of Ottumwa, the line of

FIG. 4.—ANCHOR COAL-MINE, CENTREVILLE, IOWA.

active mining-camps swings west, including Mystic and Centreville in Iowa, and Mendota, Stahl and Milan in Missouri. It is at these points that the upper bed, already mentioned, is mined. The lower measures cropping out east of this latter group of mines are not now producing much, though in earlier years they yielded important supplies of coal. South of Milan, the line sweeps in a semicircle to the south-west, keeping relatively close to the edge of the coal-field, and passing through Macon, Randolph, Ray, Lafayette, Bates and Vernon counties. The important mining towns of Bevier, Huntsville, Richmond, Higginsville, and Rich Hill, each mark the crossing of the productive zone by important railways. The latter have not only been the chief agents in

the development of these coal-fields, but afford the largest market for the output. In Iowa, in 1897, 49 per cent. of the total output was used by them, and they carried 43 per cent. to market. The relations between the railways and the coal-companies are naturally very intimate. In a large number of cases, the two properties are owned by the same parties, though the business is in most cases carried on under different company names. In any event, it is the policy of the railway as much as any other factor which determines the advisability or non-advisability of opening a mine.

In many cases, the coal-companies own in fee the land mined. Most of the country is farm-land, and large tracts can be purchased in favourable locations at from \$20 to \$40 (£4 to £8) per acre. It is customary to option an area, agreeing before prospecting to purchase the land at a stated price or to pay royalty at a fixed percentage for all coal mined under the land in question, in case the prospecting proves favourable. The royalty varies greatly with the thickness and character of the coal and the demand for leases. It usually runs from 4 to 15 cents. per ton, though some old leases at 20 cents. per ton are still running. It is frequently agreed that the royalty shall be paid at the rate of a certain number of dollars per month, whether the coal be actually mined or not, the coal-company reserving the right to mine later. Occasionally, the mineral rights are directly purchased, but it is usually cheaper to buy land in fee, and then as opportunity offers to sell the surface rights.

In Vernon and Bates counties, Missouri, and the adjacent portion of Kansas, the conditions are slightly different from those farther north. This region, which is known as the Pittsburg field (from its chief city Pittsburg, Kansas), has many of the resources which have made the older district of the same name in Pennsylvania so famous. It is situated at the edge of the richest American lead and zinc-field, and has important smelting interests. The coal mined comes from the Cherokee beds. In contrast with the irregular, pockety nature of the beds mined farther north, the Cherokee coal is known to extend over a very considerable area. A general section of the strata in the vicinity of Scammon, Kansas, would be as follows :—

6. Surface-drift and slate	0 to 30 feet.
5. **COAL,** *Top Vein*	6 inches.
4. Black and white slate	4 to 5 feet.
3. **COAL,** *Middle Vein*	16 to 21 inches.
2. Black and blue slate	6 to 30 feet.
1. **COAL,** *Cherokee Seam*...	3 to 10 feet.

The strata have a gentle dip to the north-west and the underlying Lower Carboniferous beds crop out a few miles to the south-east. As a

result, the depth to the lower coal, the bed principally worked, varies considerably. At Scammon, the mines range in depth from 50 to 90 feet. Near there, the beds crop out, and coal is mined by stripping.*

The upper bed is mined at No. 8 mine of the South-western Coal and Improvement Company, located at Mineral, Kansas. At this point, the seam is about 2 feet thick, and has been opened up by longwall workings. It is covered by 8 to 15 feet of black slate, over which is 36 feet of surface-dirt. The coal was originally opened up with room-and-pillar work, and Independent mining-machines were used. The rooms were driven 50 feet wide, and the under-cut made 5 inches below the coal in the fire-clay. It was found that to make a 4 feet undercut, about 12 feet of clear room at the face was needed. In so thin a bed the movement of the machines from one part of the mine to the other entailed considerable expense, and the ready separation of the coal from the fire-clay

FIG. 5.—FRONTENAC COAL-MINE, PITTSBURG, KANSAS.

also gave some difficulty. It was decided to change the work and a Link-belt longwall machine was being installed at the time that the writer visited the mine. This machine consists essentially of a steel box enclosing a motor and suitable gearing, and arranged to slide forward on a movable track. The motive power is applied by means of a drum and a wire-rope attached to a post ahead. The cutting is done by a horizontal arm projecting at right angles. Around the end of this

* The Coal-measures and mining methods of Kansas have been recently described by Messrs. Haworth and Crane in *Univ. Geological Survey, Kansas*, vol. iii., 347 pages, Topeka, 1898.

is run a chain armed with picks similar to those used in the ordinary mining-machine. With machine-work, this upper seam yields only 10 per cent. of fine sizes, while the lower bed, as ordinarily worked by shooting off the solid, makes but 50 to 60 per cent. of lump coal.

In this district, the coal is usually paid for as mine-run, and is weighed in the mine-cars before hoisting, or just before dumping into the screens. The coal passes, first, over a 14 feet grizzley placed at an angle of 28 degrees, and set with $\frac{7}{8}$ inch bars. The fine coals from these bars drop upon a series of perforated iron-plates, which receive a gentle vibratory motion from a small engine, so that the coal passes through the system. This type of screen is common throughout the district.

The mine-work is room-and-pillar, with cross-entries at intervals of 300 feet, rooms 22 feet wide, 8 feet between rooms, and with 12 feet pillars along entries. The coal lies very even, and the work is very regular. The highest roll noted was 4 feet, and in one mine a single mule pulls 7 tons per trip on a $\frac{1}{2}$ mile haul. Most of the tramming is accordingly done by mule-power, about 22 mules being needed for an output of 900 tons per day. The cars are the usual wooden boxes, with a capacity of 1,300 to 2,000 pounds, running with loose wheels on a 36 inches gauge railway, with about 12 pounds rails.

The mines are opened by means of 7 by 14 feet shafts, and the top works are about the same as those seen farther north. In some of the mines of the Central Coal and Coke Company and other large operators, first-motion hoisting engines are used, though the second-motion engine is more common. At No. 7 shaft of the South-western Coal and Improvement Company, a first-motion engine hoists from a 110 feet shaft in 6 seconds, with $6\frac{1}{2}$ revolutions of the drum. This shaft has an automatic dump, but has rather awkward arrangements below, the coal being weighed in the mine. Two cagers, two boys, and a weighman work below, while one man is stationed on the top. The Nelson mine of the Central Coal and Coke Company has a second-motion engine, and four cars per minute are hoisted. One of the Weir City mines, with the same hoist, takes out twice as many cars with a first-motion engine. This is of interest, because of the contention that first-motion engines do not have any great advantage in shallow mines, and the fact is significant, despite the differences in top arrangement, etc., which contribute somewhat to the results. In general, the mines of the region hoist from 450 to 2,000 tons per day, the average mine having a daily output of about 900 tons, and working out about 160 acres per shaft. Here, as farther north, shaft-sinking is cheaper than long underground hauls.

There is little water to contend with, regular pumping being rare, and no gas in dangerous quantities is found. An exceptionally small amount of timber is used, and no extensive faults or rolls are encountered. Aside from clay-slips, which are very common and occasionally carry water, there is nothing to hinder the most extensive development.

There are a large number of Italian miners in the region, some negroes and some Slavs. Anglo-Saxons are few, and yet there are some large mines which employ them entirely.

While close competition has in recent years reduced considerably both the price of coal and the profits of mining, it is still a paying field. The low cost of mining may be inferred from the facts that entry work costs from \$1·40 to \$3·20 (5s. 10d. to 13s. 4d.) per yard, the latter price being paid only for work in barren ground, and last summer the miners were being paid 87 cents (3s. 7½d.) per ton for lump coal, or 52 cents (2s. 2d.) for mine-run. It is easy to place contracts for coal at 25 cents (1s. 0½d.) per ton more than the mining rate, from which the low cost of general expenses may be estimated. Some coal has been sold recently at even lower rates.

The Arkansas-Indian Territory Coal-field.

The southern portion of the Western Interior coal-field differs in many important particulars from the northern portion. The great limestone member which is so important in the latter region has not as yet been positively recognized to the south of Kansas. Even in the latter state, the Missourian includes, as compared with the region to the north, a relatively small amount of limestone, and in Arkansas and Indian Territory the limestones are practically absent, at least, so far as the coal-field has been studied. The Coal-measures of the region include a great thickness of sandstones and shales. The hard sandstone beds are quite persistent, and in weathering stand up above the shales, forming a series of "hog-backs" which are of considerable aid in unravelling the stratigraphy of the region. The beds have been thrown into a series of east-and-west folds, of increasing intensity to the south-east.

The recent erosion has cut out a relatively well developed grade-plain, above which the mountain-ridges rise 1,200 to 1,600 feet. A considerable number of these mountain-masses are detached, and they include both anticlines and synclines. To the south-east, the folds are closer and more compressed, and faulting becomes important. To the north and west, the folds are broader and shallower, and faulting is

practically absent. The region has never been mapped in detail, and all the knowledge that we have of its geology has been derived from various reconnaissances. It is obvious that no very certain correlations can be made until more careful studies have been carried on.

Omitting the mention of briefer papers, the most satisfactory information may be obtained from Mr. Winslow's report on the Arkansas coal-seams,* a paper by Mr. Chance on the "Geology of the Choctaw Coal-field,"† and a recently issued paper by Dr. N. F. Drake giving the results of a reconnaissance of the coal-fields of Indian Territory.‡ Mr. Winslow's report was preliminary to a fuller paper which was never published. He gives a map of the greater portion of the Arkansas field on a scale of 4 miles to 1 inch, and the various cuts with the descriptive matter make the main features of the field clear.

Without attempting to correlate his divisions with those found elsewhere, he has mapped the Upper or Western coal-bearing division and a Lower or Eastern coal-bearing division with an Intermediate Barren

FIG. 6.—BONANZA COAL-MINE, ARKANSAS.

division. The more important mines are found in the area covered by the Upper division, and are situated from 15 to 30 miles south-east of Fort Smith. The Huntington, Hackett, and Jenny Lind mines are among the older and better-known mines. The Bonanza mine of the

* *Arkansas Geological Survey, Annual Report*, 1888, vol. iii., 122 pages.

† *Transactions of the American Institute of Mining Engineers*, 1889-90, vol. xviii., pages 653-661.

‡ *Proceedings of the American Philosophical Society*, vol. xxxvi., No. 156.

Central Coal & Coke Company is working on the western extension of the Jenny Lind coal-seam, and may be more specifically described, since, in equipment and general methods of working it is quite representative of the larger mines of the region.

The Bonanza mine is located in the extreme western portion of Sebastian county, Arkansas, about 10 miles south of Fort Smith on the St. Louis and San Francisco railway. The coal is delivered to the Pittsburg and Gulf railway at Poteau, 20 miles south-west, by the Choctaw and Arkansas railway, which has running powers over the St. Louis and San Francisco railway, but is owned by the coal-company. The field is the western extension of the Jenny Lind, and its position with reference to the general geology of the region is excellently shown on the map accompanying the report by Mr. Winslow already referred to. The coal occurs near the base of the Upper or Western coal-bearing division of the Coal-measures as defined by him: it is a semi-anthracite, and in appearance is clean and glistening, showing on fractured surfaces a sub-metallic lustre. A section measured in the mine gave the following details:—

	Feet.	Inches.
5. Roof-shale, hard, grey, siliceous	2	+
4. **COAL,** *Upper Bench*	2	8
3. Clay, parting		2
2. **COAL,** *Lower Bench*	2	2
1. Shale, grey, hard		8 +

The thickness of the roof and bottom-shale was not measured, but is known to be considerable. At points, its upper portion is bituminous, and is known as "black jack." The clay-parting is uniform, and is the only dirt-band in the coal. There are no sulphur balls or bone coal, so that with ordinary care very clean coal can be loaded. The bed varies but little in thickness. At one point, it decreases to barely 4 feet and at another it is over 6 feet, but the average of 5 feet is well maintained. There are no rolls or swamps such as are common further north, and there is very little faulting. One small slip with a throw of a few feet was observed. The bed has a regular dip to the north of about 10 feet per 100. It crops out south of the shaft along the flank of the anticlinal ridge between Bonanza and Jensen, and was originally worked along the outcrop by stripping. It has been traced by diamond drilling over an area of about 1,500 acres, and is known to extend to a distance of ¾ mile from the outcrop where it lies at a depth of 387 feet. It probably extends much farther, but under present conditions deeper working would hardly pay.

The mine is worked by means of a double-compartment hoisting shaft, with a second escape and air-shaft a short distance east. The coal is shot from the solid. The mine-cars are collected by mules, of which there are fourteen in the mine, in trips of two cars each. They are taken to the gravity or engine-planes, according as the entry is worked to the rise or the dip. The work is room-and-pillar, double entry with 8 feet of coal between the rooms and the entry-pillars are 14 by 18 feet. The rooms are narrow, less than 25 feet wide, and the work is all manual. About 230 miners are employed, and with a second-motion engine 1,100 tons a day were being hoisted at the time the mine was visited. The coal is dumped by hand and weighed in a hopper. From the latter, it is dumped a second time to the screens. It first passes over ordinary $\frac{7}{8}$ inch grizzleys, yielding about 75 per cent. of lump coal. The fine coal is passed over shaking-screens with perforated iron bottoms, driven by a separate engine under the screen. The mine is ventilated by a 15 feet fan, driven by a third engine placed in the fan-house. The three engines and boilers are cared for by one engineer and two firemen. There are four cagers below and four top men. By putting in an automatic dump, it should be possible to decrease this number, and with a first-motion engine at least 100 tons a day more could be hoisted. As it is, however, the mine falls but a few tons below the Arkansas record for daily output.

In the region immediately west of the Arkansas boundary line, there is not just at present much mining. Coal occurs in Sugar Loaf and Cavaniol (or Kavanal) mountains, as well as on the lowland plain between. The most ambitious attempt to open up the beds was that of the Kavanal Coal and Railway Company. This corporation built a track from Poteau up the side of the mountain to the mouth of their slope, and opened up a mine. The coal lies about 300 feet above the lowland, and pitches into the mountain with a dip of 5 degrees. The mountain is a syncline, and the outcrop of the coal has been traced entirely round it. The bed is from 3 to 4 feet in thickness, clean and of excellent quality. It could be easily mined, and there seems no good reason for the financial reverses which forced the closing of the mine.

The main mining activity in Indian Territory is in the vicinity of McAlester and Krebs, about 70 miles west of the state boundary line. This region has been studied by Mr. H. M. Chance, and his results will be found in the paper already cited. The Coal-measures of the region consist of shales and sandstones which, according to his measurements, have a minimum thickness of 8,500 feet. The Mayberry, Secor,

Norman, McAlester and Grady coal-seams were distinguished and partially mapped. The Mayberry, McAlester and Grady beds have a wide distribution, a good thickness and are considered economically important. The Grady group of coal-seams is found immediately above the basal sandstone. The McAlester coal-seam lies about 1,200 feet above the Grady. The coal-bed lies in a series of synclinal basins, with moderately steep dips at the outcrop and flat coal near the centre. The beds are 4 to 6 feet thick, the coal is of excellent quality, and the mining conditions are favourable. The Mayberry coal-seam is the one mentioned as having been mined in Cavaniol or Kavanagh mountain, and Mr. Chance considers it to be the equivalent of the Huntington-Jenny-Lind coal. Dr. Drake on the other hand believes that the latter is the equivalent of the Grady coal-seam. In the absence of detailed maps and sections, it is hard to make sure of these correlations, though the writer's own brief experience in the region leads him to believe that the Arkansas coal-seams were certainly lower than the Mayberry horizon. Change of dip and even slight faults may, however, prove so easily deceptive that it is perhaps best to reserve opinion until more is known.

With regard to the age of the Coal-measures and their correlations with the divisions noted farther north there is also room for considerable question. The beds are almost entirely sandstones and shales, and are but sparingly fossiliferous. Between them and the Missouri-Kansas field is the western end of the Ozark series, here an area of open gentle foldings. The Arkansas measures themselves have been rather sharply folded and show some faulting. Under these circumstances, correlation by stratigraphical evidence alone is uncertain, until more detailed work has been done. Lithologically the rocks near Bonanza resemble the Des Moines beds of the northern coal-fields. Their relations to the Lower Carboniferous rocks separating the two areas are apparently such as to at least not forbid the correlation of the two divisions. Dr. J. C. Branner* has considered the beds as probably Permo-Carboniferous. Dr. Drake has divided the series into two groups, the Poteau and the Cavaniol, both being considered to lie below the Permian. The Cavaniol is believed to be the equivalent of the Missourian formation of Kansas. These correlations are based largely upon the evidence derived from fossils, but a little experience with the Carboniferous-measures of the interior quickly shows that the fossils alone are of rather uncertain value in the correlation of minor divisions over wide areas. It is not difficult to find most of the common Missourian forms well down in the Des Moines beds,

* *U.S.A. Geological Survey, Mineral Resources*, 1892, page 304.

wherever limestone occurs. There is rarely sufficient difference in the fauna of the separate divisions to make certain the correlation of widely separated beds.

Dr. Keyes* considers the whole of the Coal-measures of the Arkansas-Indian Territory field to be the thickened southern extension of the Des Moines series. It is certainly difficult to find in the region anything similar to the Missourian as developed in the north. This absence of all rocks of the Missourian type, despite their usual great persistence, and the difficulties, in view of the present known distribution of the Missourian, in conceiving a distribution which would reconcile this correlation with the known facts, mitigates against the view that any portion of the beds is Missourian. While the matter is still open, it seems not improbable that eventually the Arkansas measures will be found to be southern equivalents, greatly thickened, of the Des Moines productive formation of the Iowa-Missouri-Kansas field. The dynamic action which the beds have suffered, but more especially the differences in the conditions of deposition, evidenced by the greater thickness of the measures, are sufficient to account for the change in the character of the coal.

The Carboniferous area in Texas has been supposed to be a portion of the Arkansas-Indian Territory coal-field. Mr. Robert T. Hill, who is quite familiar with the region, thinks, however, that it is quite distinct. He states that the merchantable coals of the territory do not outcrop south of the great folded east-and-west axis of the Ouachita mountain system, which extends across southern Indian Territory and constitutes a complete barrier between the natural features of the Missourian and Texan regions. South of this system, the Coal-measures occur under entirely different structural conditions, having been submerged during subsequent geological epochs, which submersion seems to have charged them with certain impurities that render them of less commercial value than the coals of similar age from the unsubmerged areas.† The coals of the Texan area are not of such quality as to compete seriously with those immediately north. They come into competition rather with lignites, which occur throughout the region. In 1897, 395,927 short tons of bituminous coal were produced and 211,514 short tons of lignite. The bituminous mines are located in Erath, Montague, Palo Pinto, Parker and Webb counties. The mines are small, and the output is absorbed by the local trade.

* *Engineering and Mining Journal*, vol. lxv., pages 253 and 280.

† *U.S.A. Geological Survey, Mineral Resources*, 1891, page 326.

Character of the Western Interior Coal-seams.

As might be expected from the great extent of the field and the wide variation in the original and present condition of the beds found in it, there is a considerable variety in the quality of the coal found. All grades from semi-anthracite to free-burning non-coking coal, including gas-coal, cannel and coking-coals, occur. Representative analyses are given in the table on the following page.

It will be noticed that the coals of Iowa and northern Missouri are relatively low in fixed carbon and high in volatile matter. They would in many cases make excellent gas-coal if it were not for the sulphur which is uniformly high. The percentages of ash and moisture are also high. In appearance, they are usually laminated and show a dull fracture-surface. They are fair steaming-coals, and are acceptable for local manufacturing and domestic use. It is, however, obvious that they can never compete with the better coals to the east and south in outside markets. The simplicity of the mining conditions which allows them to be easily and cheaply mined, has been the main factor in promoting their development.

The Mystic coal is a glance coal, breaking with a clear conchoidal fracture, and showing little lamination. It is brittle and must be carefully handled. It is a favourite for domestic use, though not quite so good a steaming-coal as the others. Several of the coals of the region give indications of coking, but none could be coked to advantage without preliminary washing to reduce the sulphur and ash. Trade conditions are such, that no coal is coked in Iowa or northern Missouri. A small amount is made in the Pittsburg (Kansas) region for use by zinc-smelters.

The Indian Territory coal ranks still higher, having lower sulphur and ash, and being higher in fixed carbon. The analysis of the Mayberry bed quoted is exceptionally high in ash and sulphur, other determinations being: ash 3·15, 2·11 and 9·57, and sulphur 1·21 and 0·87. This analysis is given, as it is the only one at hand of coal from Cavaniol mountain. The fault is probably in the sample. Indian Territory coals are quick firing, clean and easily handled. They are, at most points, good coking-coals, and are, undoubtedly, the most satisfactory steaming-coals for general purpose in the entire field. The cost of mining is a little higher than elsewhere, as royalties average higher than in the states. The

Name of Mine.	State.	Locality.	Fixed Carbon.	Volatile Comb.	Moisture.	Ash.	Sulphur.
Collins 6	Iowa	*Fort Dodge District	45·54	39·52	7·48	8·44	5·24
Craig "Cannel"	,, ...	* ,, ,, ...	39·22	39·04	5·87	15·87	7·12
Dalby	,, ...	*Boone District	47·93	44·21	2·13	5·73	3·82
Gibson	,, ...	*Des Moines District	43·17	40·06	7·04	9·72	4·25
American	,, ...	*Oskaloosa District	45·29	45 42	5·16	4·13	3·71
Forbush	,, ...	*Mystic coal	47·14	35·84	9·70	7·31	4·41
Rich Hill	Missouri	†Bates County	41·14	42·62	2·54	13·70	4·51
Johnson County Coal-mining Co.	,, ...	†Montserrat, Johnson County	34·69	32·25	6·16	26·90	14·71
Lexington Coal-mining Co. ..	,, ...	†Lafayette County	45·32	36·34	10·63	7·71	2·93
Osage Coal and Mining Co. ...	,, ...	†Elliott District	47 54	41·90	8·22	2·34	1·81
Cherokee coal	Kansas	‡Weir City Mine, Cent. C. and C. Co.	52·69	26·69	2·21	—	8·41
,, ,, ...	,, ...	§Average of several analyses	52·45	36·77	1·94	8·84	—
Grady coal...	Indian Territory ...	‖Grady Basin, average of 7 analyses ...	51 78	40·21	1·79	4·88	1·33
McAlester coal	,, ,, ...	‖Krebs District	53·40	37·17	1·80	6·72	0·90
Mayberry bed	,, ,, ...	¶Poteau District	64·54	17·23	1·36	12·46	4·40
Huntington	Arkansas	**Sebastian County	77·57	15·55	0·93	4·85	1·14
Hackett	,, ...	** ,, ,, ...	73·87	14·92	0·85	9·04	1·32
Petty (Jenny Lind)	,, ...	** ,, ,, ...	76·22	13·33	1·78	7·05	1·62
Bonanza	,, ...	‡ ,, ,, ...	78·02	18·37	0·50	2·25	0·83

* Mr. C. R. Keyes, *Iowa Geological Survey*, vol. ii., 1894. † *U.S.A. Geological Survey, Mineral Resources*, 1887, page 274. ‡ Empire Zinc Company. § Mr. Baily, *Trans. Kansas Assoc. Sci.*, vol. xi., page 46. ‖ Mr. H. M. Chance, *Transactions of the American Institute of Mining Engineers*, 1889-90, vol. xviii., page 656. ¶ Mr. Drnk, *Proceedings of the American Philosophical Society*, vol. xxxvi., No. 156. ** Mr. Winslow, *Arkansas Geological Survey, Annual Report*, 1888, vol. iii.

absence of any important local demand, and the difficulties and expense incident to mining in a wild and thinly settled area, have hindered the development of the mines.

The Arkansas coals are semi-bituminous and semi-anthracitic. Their high fixed carbon, low sulphur, ash and moisture, stamp them as coals of great efficiency. In appearance they are clean and glistening, and show little lamination. They are more fragile than is usual with coals of their class. They are practically smokeless, and with care in handling make excellent locomotive coals. They must, however, be burned over a special grate with large air-space and strong draught. The coal must be spread even and thin, and frequently raked. The Kansas City, Pittsburg and Gulf railway burns the Bonanza coal on its southern division, and the Stahl, Missouri coal on the Omaha line. Mr. I. C. Hubble, fuel-agent of the road, states that Bonanza coal has about 50 per cent. greater efficiency than the northern coal. The St. Louis Sampling and Testing-works found, as a result of tests made for the Arkansas Geological Survey, that for Huntington coal, the ratio of heating-surface should be about 5·3 times the square root of the height of the stacks. For Jenny Lind, this ratio should be about 6, and for Coal Hill, 4. With these properties and fairly clean flues, these coals should evaporate 8·5, 8·4 and 7·0 pounds of water per pound of coal respectively.

The following table shows the number of pounds of coal in each case equal to one cord of standard oak-wood as determined by the U.S. Quartermaster-General. It will be useful for comparison, even though it be recognized that all coals are not equally efficient under the same conditions, and that by varying the type of grate one may often largely increase the efficiency of a poor coal.

TABLE IV.—GOVERNMENT TESTS OF CERTAIN COALS IN COMPARISON WITH 1 CORD* OF AVERAGE OAK-WOOD.

	Lbs.		Lbs.
Bonanza, Arkansas	1,572	Leavenworth, Kansas ...	2,307
Jenny Lind, Arkansas ...	1,675	Rich Hill, Missouri	2,369
Huntington, Arkansas ...	1,765	Pleasant Hill, Utah	2,407
McAlester, Indian Territory	1,950	Lad, Illinois (third vein) ...	2,660
Weir, Kansas (lump) ...	1,988	Fort Scott, Kansas	2,670
Pittsburg, Kansas (Cherokee bed)	2,069	Lexington, Missouri	2,734
Weir, Kansas (run of mine)	2,165	Spring Valley, Illinois ...	2,751
Alabama	2,188	Hocking Valley, Ohio ...	2,971
Tennessee	2,219	Streator, Illinois	3,076
Colorado	2,299	Boulder Valley, Colorado ...	3,176
		Pennsylvania, anthracite ...	1,700

* A cord of wood measures 4 feet by 4 feet by 8 feet, and has a volume of 128 cubic feet.

MARKETS.

Throughout the western interior coal-field, the railways are the chief users of coal. The area is mainly within the great farming and grain-producing region of America, and railway traffic is a relatively important industry. Manufacturing is as yet but little carried on, though certain classes of goods are made in quantity, and other lines of manufacture are bound in time to develop. In the northern portion of the field, the winters are severe and domestic consumption is important. Towards the south, the shorter, less severe winters, the greater amount of timber, and the decrease in the density of the population, all tend to reduce the output of the mines so far as they are dependent upon domestic trade. The chief export trade of the Iowa coal-operators is with the states lying to the north and west, where the coal is the main staple for domestic and locomotive use. It is well adapted to this work, can be produced cheaply, and has geographical advantages which assure it a future in the trade. The Missouri and Kansas mines ship west and south-west into the prairie region, the coal being adapted to the same uses and having the same advantages that Iowa mines enjoy in the north-western trade. It might be thought that, in view of the presence of the Mississippi and its tributaries and the cheapness of water-transportation, this northern portion of the field should be able to reach some of the distinctively lower river-markets. It should be remembered, however, that the states of West Virginia, Pennsylvania, Ohio, Indiana, Illinois and Kentucky enjoy the same advantages, and furthermore, have better coal and frequently lower mining costs. A cheaper class of labour is employed in these eastern states, the operations are usually on a larger scale, and the trade is following lines already established. All these facts make it hopeless to expect any important eastward movement of these coals.

The coals of the Arkansas-Indian Territory field, as already suggested, do not have much of a domestic trade. Portions of the country are well adapted to certain lines of manufacturing, and in time the growth of local industries will considerably increase the demand for coal. At present, however, the mines are even more dependent than elsewhere on the railways. There has been recently some activity in railway-building in the region, and an effort is being made to build up the Gulf ports. The direct exportation of the great grain crops of the prairie states and the importation of foreign goods through the new but geographically nearer ports on the Gulf rather than the old-established ports of the Atlantic seaboard has long been the dream of the region.

There have been railways built to accommodate this traffic, but sooner or later they have passed into the hands of interests better served by maintaining the *status quo*, and goods have continued to be shipped *via* the eastern routes. Recently, the Kansas City, Pittsburg and Gulf railway has been built from the first-named city to Port Arthur by Holland capitalists to occupy this field. The railway has shortened the distance from Kansas City to the sea by 300 miles, and has at the same time brought the coal-fields much nearer to the docks. Previous to the completion of this road the McAlester coal had been 590 miles from the Galveston docks. With the completion of a short connecting road, now ready for the rails, the distance to Port Arthur will be 500 miles. The distance from Poteau, at which point the Bonanza coal is delivered to the Kansas City, Pittsburg and Gulf railway, and at which point the Mayberry coal is mined, is 460 miles. The new road accordingly cuts off more than 100 miles of the distance which coal had previously to travel to reach tide-water. It seems probable that as a result of these changes the mines of this coal-field will soon be able to enter the tide-water trade. Alabama coals are now hauled 276 miles to reach Gulf ports, and Pocahontas coals travel 350 miles to Norfolk. With the completion of the contemplated coal-docks at Port Arthur, there can be no doubt that these western coals will become an important factor in the Gulf trade. The western Arkansas coal is well adapted to marine use, and already it is found that steamers seek this coal. Analyses of Bonanza and Pocahontas coals are placed side by side below to call attention to their close similarity. The analysis of the former is the one already given as made for the Empire Zinc Company, and that of the latter is by Mr. E. V. d'Invilliers.

	Bonanza.	Pocahontas.
Moisture	0·50	1·011
Volatile and combustible matter	18·37	18·812
Fixed carbon	78·02	74·256
Ash	2·25	5·191
Sulphur	0·83	0·730
Totals	99·97	100·000

In view of the fact that Pocahontas is the standard marine coal of America, and has been shown by repeated tests to be the best coal for ocean-going vessels, the comparison is wondrously significant. The western Arkansas coals are rather more fragile than is altogether desirable in a bunker coal. Since, however, in order to get the best results they must be fed fine, this is not so serious a matter. After the stokers learn to handle the coal, and grates fitted to its use are put in, the

results will be found very good indeed. With so many favourable conditions there is undoubtedly an excellent opportunity for the development of a coaling trade. Whether or not a considerable export trade can be developed is more open to question. It will depend largely upon the means adopted, but it is fair to suppose that, with careful organization and close attention to costs, the feat can be accomplished, as the superior character of the coal is bound to influence results in the long run.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

SPECIAL MEETING,

HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT, OCTOBER 10TH, 1898.

MR. JOEL SETTLE, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected :—

MEMBERS—

Mr. HERBERT BRIGGS, Mechanical Engineer, Oakhill, Stoke-upon-Trent.

Mr. WILLIAM HOLME, Engineer, 70, Apedale Road, Chesterton, Newcastle, Staffordshire.

Mr. JOHN THOMAS STOBBS, Mining Lecturer to the County Council, 54, Havelock Street, Stoke-upon-Trent.

Mr. HENRY SUMNALL, Colliery Manager, High Carr Collieries, Chesterton, Newcastle, Staffordshire.

Mr. THOMAS TWIST, Colliery Manager, Spring Wood, Chesterton, Newcastle, Staffordshire.

Mr. RICHARD HANBURY WAINFORD, Engineer, Victoria Chambers, Stoke-upon-Trent.

STUDENT—

Mr. THOMAS YATES, Surveyor, Brynkinalt Collieries, Chirk, near Ruabon.

The officers for the ensuing year were nominated.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,

NOVEMBER 14TH, 1898.

MR. JOEL SETTLE, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected:—

MEMBER—

Mr. SAMUEL ATHERTON, Colliery Owner, Hanwood and Shorthill Collieries, near Shrewsbury.

STUDENTS—

Mr. JOHN ARTHUR COLE, Biddulph Valley Ironworks, Stoke-upon-Trent.

Mr. BERNARD HEWITT, Whitfield Collieries, Norton-in-the-Moors, Stoke-upon-Trent.

The annual reports of the Council and of the Finance Committee were read as follows:—

ANNUAL REPORT OF THE COUNCIL.

The Council of the Institute have pleasure in presenting their Annual Report; the membership shows a decrease of 1. During the last year there have been 4 Members, 3 Associates and 3 Students elected, and the Institute has lost through death 1 Honorary Member, Mr. R. P. W. Oswald, and 2 Members, Mr. John Street and Mr. B. D. Viggars; by resignation, 6 Members, 1 Associate Member and 1 Associate; 8 Students have been transferred to the list of Associates, 1 Associate to the list of Members, and 1 Member to the list of Associates.

The following table shows the alterations that have taken place:—

	Year 1896-97.	Year 1897-98.
Honorary Members	6	5
Life Member	1	1
Members	116	112
Associate Members	5	4
Associates	36	46
Students	19	14
Totals	183	182

General meetings have been held in the months of September (Special), October (Annual), December, February, May, July and October (Special), at which the following valuable papers were read, and together with these others published in the *Transactions* of The Institution of Mining Engineers were discussed :—

"Safety-lamps." By Mr. W. Best.
"Cheshire Salt-mines." By Mr. C. E. de Rance.
"New Hydraulic Mining-cartridge." By Mr. Jas. Tonge.
"The Workmen's Compensation Act." By Mr. E. B. Wain.

The Federated Institution of Mining Engineers, now The Institution of Mining Engineers, held their Annual General Meeting in Edinburgh in September, and two General Meetings, one at Newcastle-upon-Tyne in February, and one in London in May ; they will hold their next meeting in this district on February 22nd and 23rd, 1899, and the Council hope that all interested will use every effort to make the same successful. An interesting Excursion Meeting was held in Belgium in June, 1897.

The following is an enumeration by subjects of the papers read before The Institution of Mining Engineers and affiliated Institutes :—

Presidential Addresses	4
Geology	17
Mining Engineering	10
Mechanical Engineering	9
Mine-ventilation, Safety-appliances, etc.	5
Legislation	2
Electricity and its Applications	2
Explosives	8
Shipment of Coal	4
Metallurgy	4
Miscellaneous	9
Total	74

It is with pleasure that the Council call your attention to the mining classes held during the last winter session in several of the Pottery towns. The prizes were distributed in the Town Hall, Stoke-upon-Trent, by Mr. W. N. Atkinson, H.M. Inspector of Mines, Mr. James C. Cadman occupying the chair, when the following awards were made :—1 studentship of £3, 3 of £2 each, 15 of £1 each, 1 prize of £1, 2 prizes of 10s. each, 4 prizes of 7s. 6d. each, and 5 of 5s. each. The courses of lectures mentioned in the last report were successfully

held, and fairly well attended. The lectures and lecturers were:—"The Geology of the World as applied to North Staffordshire," by Mr. C. E. de Rance; "The Chemistry of Mines," by Prof. H. B. Dixon; "The Application of Electrical and Mechanical Engineering to Mining," by Prof. F. W. Burstall; and "The Occurrence and Properties of Iron-ores and the Methods whereby they are Converted into Cast-iron, Wrought-iron and Steel," by Mr. Thomas Turner.

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The receipts from subscriptions and arrears amount to £249 1s. 6d., or £34 16s. 4d. less than last year. There has been an additional call of 2s. per member from The Institution of Mining Engineers, amounting to £15 8s. 0d., and a loss upon the lectures of £36 18s. 6d. The bank balance is £148 13s. 8d. as against £183 10s. 0d. last year, and the arrears have increased by £18 18s. 0d., although every member has had five applications for the same.

The reports were adopted.

ELECTION OF OFFICERS, 1898-99.

PRESIDENT.

Mr. J. C. CADMAN.

VICE-PRESIDENTS.

Mr. W. N. ATKINSON. | Mr. T. M. FAVELL. | Mr. A. M. HENSHAW.

TREASURER.

Mr. H. M. MAKEPEACE.

SECRETARY.

Mr. J. R. HAINES.

COUNCIL.

Mr. T. ASHWORTH.	Mr. J. NEWTON.
Mr. JOHN HEATH.	Mr. C. E. DE RANCE.
Mr. G. P. HYSLOP.	Mr. F. RIGBY.
Mr. J. MADDOCK.	Mr. F. SILVESTER.
Mr. G. A. MILLWARD.	Mr. T. E. STOREY.
Mr. G. A. MITCHESON.	Mr. B. WOODWORTH.

Col. J. STRICK proposed a vote of thanks to Mr. Joel Settle for his past services as President.

Mr. E. B. WAIN seconded the motion, which was carried unanimously, and the vote was duly acknowledged.

Owing to the absence of the President (Mr. J. C. Cadman) through indisposition, his inaugural address was read by Mr. E. B. WAIN as follows:—

PRESIDENTIAL ADDRESS.

By J. C. CADMAN.

First, let me thank you for the honour which you have conferred upon me by electing me your President. I feel somewhat doubtful of being able to do justice to the position, to fulfil the many duties required, and to give that satisfaction which so many of my predecessors have done ; but I can only promise to do my best for the welfare and advancement of our Institute, and I beg to ask the Council and members for their kindly help and assistance during my term of office.

In addressing you to-day as President, and one of the founders of the North Staffordshire Institute of Mining and Mechanical Engineers, I feel that I may be allowed to refer to some of the past work done by the members before it became federated.

In calling attention to some of its most important papers and discussions, I do so with the hope that this will be an incentive to some of our junior members, and that they may take an active interest in its work, by reading papers or opening discussions on papers read before some of our kindred societies.

On December 5th, 1872, a meeting was called to discuss the working of the Coal-mines Regulation Act which was then about to come into force, and one of the results of that meeting was the formation of our Institute. At an adjourned meeting held on December 12th, a further number of members were enrolled. On January 6th, 1873, the President and officers were elected, and the first annual meeting was held on February 10th, 1873, when the first President, Mr. T. M. Wilkinson, delivered his Presidential address.

During 1873, the Institute, realizing that more scientific knowledge was required in mining, engaged Dr. Hill to give a series of lectures on "The Chemistry of the Mine ;" and these lectures form a valuable part of the first volume of our *Transactions*.

Our Institute has followed from time to time the example set by its first Council, by engaging eminent professors to lecture on subjects appertaining to mining before the members and anyone interested or employed in coal-mining in the district.

During 1873 the first excursion took place to the Eastwood colliery, near Nottingham, where valuable information was obtained by the members. A useful paper was also read during this year by Mr. B. Woodworth, to whom the Institute has several times been indebted for valuable and useful information.

I may here mention that of the officers elected at the first meeting one only holds office at the present time, and that is our worthy Secretary, Mr. J. R. Haines.

The second annual meeting was held on February 2nd, 1874, when the Secretary reported that the amount in hand was over £100, thus proving that the Institute had taken thorough root in the district. A very valuable paper was read on "The North Staffordshire Coal-field" by Mr. Homer, the second President. In this year also, papers were read on electric signals and colliery-boilers. A visit was also made to the Wigan district of the Lancashire coal-field, and the account of that visit contains a detailed section of the strata sunk through to a depth of 2,445 feet at the Rosebridge colliery, near Wigan. Another visit was made to the engineering-works of Mr. Adamson, at Hyde, near Manchester. In volume i., a section of the Ashley Deep pit, near Duckenfield, is also printed. The total number of Members at the end of the second year was 239, with 8 Honorary Members.

Volume ii. contains a continuation of Mr. Homer's paper on "The North Staffordshire Coal-field," with sections, analyses of some of the iron-ores, and a detailed account of the quality and value of the various coal-seams. Excursions to Leeds, Cannock Chase, North Lincolnshire, Woolwich and North Wales are also reported in this volume. Mr. G. G. André gave a series of lectures on "The Geology of Coal," which was successful and well attended. A paper was also contributed by Mr. James Ashworth on "Gunpowder." At the annual meeting, held on June 12th, 1876, Mr. D. Adamson was elected President. This volume also contains a useful paper read by the late Mr. Orlando L. Lucas on "The Destructive Results obtained by the Use of Gunpowder in Coal-mines"; this interesting paper at the time caused considerable discussion, both at our Institute and in the mining world generally, as it raised the important question of the effect of a blown-out shot in a dry and dusty mine, a subject that had before then received very scant attention.

Volume iii. shows that the Institute again realized the importance of scientific lectures, and the benefit to be derived by the district from such lectures: it contains the reports of Dr. Carnelley's lectures on "Colliery

Explosions" and "Explosive Agents," and of two lectures by Dr. F. Clowes on "The Chemistry of Combustion" and "Chemistry of Flame."

Volume iv. contains papers on "Prohibition of Blasting in Coal-mines," by Mr. W. Y. Craig, and a lecture by Prof. W. C. Williamson on "Coals and Coal-plants."

Volume v. contains the first paper by Mr. A. R. Sawyer, who from that time until he left the North Staffordshire district, gave the members a number of instructive papers.

Volume vi. contains interesting papers on "The Explosive Properties of Fire-damp and Coal-dust," by Mr. C. Lawton; on "Underground Haulage," by Mr. W. R. Wilson; and a lecture by Mr. C. M. Percy on "Winding Appliances: Past, Present, and Future."

Volume vii. contains several useful papers on "Lime Blasting," "Sinking through Quicksand," "Safety-lamps," "Underground Velocities and Illumination," and the results of "Experiments with Safety-lamps." Excursions were also made to Birmingham, Lilleshall and Liverpool.

Volume viii. contains papers on "The Temperature and Moisture of Air-currents in Mines," "A Fire-damp Indicator," and a valuable paper on "Pit-fires," by Mr. Samuel Spruce, which led to remarks and discussions on spontaneous combustion, erection of stoppings, packing, etc., and a paper on "Gob-fires," by Mr. R. P. W. Oswald. Papers were also read on "A New Safety-lamp," "Arrangements for Preventing Accidents at Level-landings in Cage-dips and Shafts," "The Method of Working Coal at Whitfield Colliery," and the results of "Experiments with Gelatine-dynamite in Water-cartridges." Excursions were made to Apedale, Knutton and Liverpool.

Volume ix. contains papers on "Compressed Air-power System," "Economy of Steam in Winding-engines," "Coal-dust," "Electric Safety-lamps," "Underground Blasting," etc., all of which led to interesting discussions. Excursions took place to Codnor Park, Dudley and Birmingham.

Volume x. of the *Transactions*, from 1889 to the period when we joined the Institution of Mining Engineers, contains papers on "Explosions;" "Electricity as applied to Mining;" "Mining at Kimberley;" "South African Coal-fields; "Mechanical Screens;" and "The Probable Extension of the Midland Coal-field." Also a lecture by Prof. F. Clowes on "Colliery Explosions, Safe Lights, and Safe Methods of getting Coal." A number of excursions were made to the Manchester Ship Canal, Electrical Exhibition, Birmingham, and Messrs. Mather & Platt's engineering works, Manchester.

In 1890, an important paper was published on "The Geological Features of the North Staffordshire Coal-field" by Mr. John Ward."

This brings me to the end of the short review which I proposed to make of work done by our Institute; and I sincerely hope that this review will induce members to come forward and read papers, so that our meetings may be made more useful, interesting and instructive, and that our Council may see their way to arrange short excursions similar to those that have taken place in the past; for all members cannot spare time to attend those very interesting exoursions which are arranged by The Institution of Mining Engineers, excursions which as a rule are spread over two or three days. I believe day-excursions, such as we used to have, if they could be arranged, to visit places of interest, and where members could see something to their advantage, or to the advantage of the district, would be as well attended in the future as they were in the past.

During the past year the Workmen's Compensation Act came into operation, but owing to the short time during which it has been in force, I cannot speak as to how it will work, although I am pleased to say that in North Staffordshire the employers are endeavouring to carry out the Act in a fair and honourable spirit, and without giving unnecessary trouble or expense to any unfortunate workman who may require its help. This Act introduces an entirely new principle of compensation, for under the old Act the workman had to prove the liability of the employer, but the Act of 1897 assumes his liability. The Act of 1880 still remains in force and can be appealed to, when the workman does not come under the new Act.

Comparing the Workmen's Compensation Act with the one proposed in Parliament by one of our former Presidents (Mr. W. Y. Craig), I cannot but believe that the system proposed by him would have worked more satisfactorily to the parties concerned than the present Act, and would have been far less liable to friction or unpleasantness.

Several other Acts referring to mining and engineering have come into operation, but are not of very great importance.

With regard to the Home Office Explosives Order, a circular has been issued by the Home Office requesting the attention of colliery-officials using inferior explosives, "although on the permitted list." At the same time, it gives the users the opportunity of having the explosives tested by the Home Office officials, if they are suspected of not being up to the standard. I think that there is one serious omission in the order, that is, should it be proved that the composition

of the explosive is not in accordance with the specification as permitted by the Home Office, a heavy fine ought to be imposed on the manufacturer; for the risk of using the inferior explosives is too serious to allow of any doubt of its not being in accordance with that allowed by the Home Secretary, when used in a dusty or gaseous seam.

The carrying out of these various Acts of Parliament naturally increases the responsibility of the officials, and at the same time adds considerably to the cost of production. It seems to me a great hardship that colliery proprietors alone have to bear this cost. What I particularly wish to point out is this. Take, for example, a lease made 10 or 20 years ago, the lessors and lessees when fixing the royalty took into consideration all other liabilities, both local and imperial. Since that time, the extra cost brought about by various Coal-mine Regulation and Compensation Acts almost amounts to a second royalty rent. I do not complain of this cost so long as it tends to the reduction of accidents and the safer working of collieries. This must naturally be of benefit to the lessor as well as the lessee. However, I do think it is unfair that the lessee should be called upon to bear the whole of this additional cost.

In my opinion, in special matters of this kind, which could not have been foreseen, it would be right that the lessor should also contribute some portion; for I have no hesitation in saying that in many cases had the lessee expected or anticipated this extra charge a very much reduced royalty would have been arranged. I think that Parliament would act wisely when passing acts of this nature to take the point above mentioned into their serious consideration.

With regard to the making of leases generally, I believe that it would be much better if leases were made on the sliding-scale system, *i.e.*, the royalty to be in proportion, per ton, to the selling price. I consider that this would be fairer all round: giving the lessor a benefit in good times, and the lessee relief when trade is bad.

The extra cost of production must be met in some way; and it is at times, owing to keen competition, very difficult to obtain an equivalent advance on the price of coal or iron-ore.

Our late President alluded, in his address, to the Corporation of Colliery Owners for increasing and maintaining the selling-price of coal with the object of making it remunerative to get. This organization is still in existence and it only requires to hold firmly together, and, members to have fuller confidence in each other, to be a lasting benefit to them and a means of their obtaining better prices. So long as its

object is to obtain a legitimate price for coal and, not attempt to force it beyond its intrinsic value, it cannot fear any outside objection.

To meet these extra charges greater attention will also have to be paid to the more economic modes of getting, haulage, draining, and raising coal. The mechanical engineers of our Institute must play a very important part in this work; it will be necessary for them to weigh over carefully in conjunction with mining engineers, the best, most improved, and economical method to be adopted. In some cases, electricity will be found the most suitable for dealing with haulage, draining, lighting, etc.; in other cases, underground circumstances point to compressed air as being the most desirable; whilst at other places, under different conditions, endless ropes are unquestionably the most effectual and economical.

Great care must also be taken in selecting winding-engines and pumping-engines; the question of using compound-engines with high-pressure steam, the form of boilers, self-acting stokers and forced draught are also worth seriously considering before making alterations or erecting a new plant. But in all cases, before deciding, every care must be taken to go thoroughly into the question from both a mechanical and mining point of view, and here I may point out that a difficulty sometimes creeps in if either one party or the other should be wedded to any one particular system.

The use of steel girders for main roads, although appearing at first to be costly, if the roads are required for any length, would eventually result in a considerable saving.

It will also be advisable to consider carefully if something cannot be done with the bye-products of collieries, *i.e.*, waste-heaps containing pyrites, marl, shale or fire-clay. At the present time, bye-products play a very important part in the successful manufacture of steel, basic slag being a valuable residual; while in iron-making, tap-cinders and breeze are now of such value that had it not been for these bye-products iron could not have been made at a profit for some years past, and I am afraid that we should have seen many more of our local ironworks closed.

In the manufacture of pig-iron, coke is largely used, and the reclaiming of bye-products by the use of such ovens as the Simon-Carvès and Semet-Solvay type will have to be adopted for the economical manufacture of coke. I firmly believe that it will become (owing to the keen competition from other districts and America) absolutely necessary in such districts as North Staffordshire, where the coal is most suitable, that such valuable bye-products as benzol, tar, ammonia, etc., should be abstracted and made

of commercial value. This saving would be the means of very much reducing the cost of coke without materially reducing its quality, and, so, in like proportion reduce the cost on the manufacture of pig-iron.

On this subject I cannot do better than refer you to an excellent paper by Prof. P. P. Bedson which appeared in the *Colliery Manager*,* and several papers have also been read on different types of this class of oven at meetings of The Institution of Mining Engineers, and are printed in the *Transactions*.

In coal and ironstone-mining, the marls and fire-clays which are continually being sent out of the mines are, in many cases, capable of being converted at a very slight cost into fire-bricks, or at least into good common brick, and this at a profit. It is now being done at several collieries in the district, and I see no reason why some of the unsightly waste-heaps in our neighbourhood cou'd not be used up in this way.

As a rule, the inaugural address of the President of such an Institute as this is confined to scientific and statistical subjects; but as the commercial element must run parallel with the advancement of science, I have no need to apologize for referring to it in my address; for we all know, should trade be bad, that very little money is available for experimental and scientific research.

At the present moment, I must congratulate the district on the improved state of trade generally; but although the Home Office statistics for 1897 show an increase of 204,062 tons of coal raised in this district, we have not reached the quantity that had been raised in previous years. The ironstone raised shows a falling off of 10,297 tons on the previous year, the actual figures being: 1897, coal, 4,992,452 tons; ironstone, 891,059 tons; and 1896, coal, 4,788,390 tons; ironstone, 901,356 tons.

Although prospects look brighter, we cannot expect them to continue for long; the usual fluctuations in trade are bound to occur sooner or later, and therefore it behoves the members to look more closely into all the economic methods of working coal and making use of the bye-products, so as to be prepared to meet these fluctuations when they come.

Another very important question requires consideration, and will, I believe, come to the front before long; this is the tariff question, from which we in the Midlands suffer all round. It was admitted in evidence before the Railway Commission a short time ago by a railway-official that about 60 per cent. of profit was made on the carriage of coal. An

* 1898, vol. xiv., page 155.

appeal has been made to the railway companies for a general reduction of their rates to London and the south, owing to the increased facility and reduced cost and competition of sea-borne coal taken into these districts and the great improvement brought about by the construction of more suitable ships, arranged in such a manner as not to unduly crush the coal; and the greater facilities now available in loading and unloading. These improvements have been the means of considerably reducing the cost of delivery below that of the various railway companies.

We have the most startling proof of this in our own district of North Staffordshire, when we find that the coal delivered to London and south of the Thames in 1892 was 294,640 tons, and in 1897 only 161,416 tons, showing a loss of 133,224 tons, or nearly one-half; and there were no special features in trade during these years to account for this serious reduction. I firmly believe that, unless the railway companies realize this fact at once, it will be of very little use to offer concessions when the trade has left the district.

The same question, I am sorry to say, is not confined to coal alone, for all the industries of North Staffordshire suffer more or less from this cause. The ironstone-trade at one time was in a much more flourishing condition than at the present moment, owing to a much larger quantity being sent out of the district. The quantity of ironstone raised in North Staffordshire in 1888 amounted to 1,629,277 tons, and in 1897 to 891,056 tons. This shows a serious decrease, chiefly in blast-furnace ore. I give a comparison of railway rates for Northampton and Lincolnshire iron-ores (which have to some extent superseded North Staffordshire ores), which the railway companies in those districts are content to accept, side by side with those charged for iron-ores from North Staffordshire, and leave them for the members to judge what the natural result must be:—

Rushton to Wolverhampton ...	69	miles at	0·49d.	per mile.
Stoke to Wolverhampton	32	,,	1·18d.	,,
Rushton to Oakengate	86	,,	0·43d.	,,
Stoke to Oakengate	34½	,,	1·25d.	,,

The total railway receipts for goods traffic amounted to nearly £48,000,000 last year, the passenger traffic amounted to about £40,000,000, and the mineral traffic alone amounted to nearly £20,000,000. This proves the importance to the railway companies of mineral traffic, and on these grounds alone, greater consideration and attention should be given to it; and when it is necessary to obtain future trade or retain old connexions when threatened, some relief should be given in the railway rates. I must apologize for introducing

this question, but I feel that it is of such vital importance for the welfare of the district, and, as a consequence, to the members of our Institute, that I hope to be forgiven.

Alluding to the Home Office statistics of last year, while deploring the number of accidents, I cannot but refer with pleasure to the reduced number in North Staffordshire, and heartily congratulate H.M. inspectors of mines upon the result of their work. The diminution also proves that the district, as a whole, is loyally endeavouring to carry out the various Acts of Parliament and suggestions made from time to time by H.M. inspectors of mines for the safety of the workmen. Mr. W. N. Atkinson reports that in 1897 there were 25 fatal accidents in North Staffordshire, and in 1896 there were 37. Over the whole of his district, including Cheshire and Shropshire, the total deaths in 1897 were 31 as against 44 in 1896. This shows a more marked improvement when we take the average for the previous 10 years, which gives 55·8 or almost double the number.

Considering the nature of the North Staffordshire coal-field, which I have no hesitation in saying, is the most difficult and dangerous in the kingdom, with steep gradients, bad roofs, gaseous seams, and subject to spontaneous combustion, we should be thankful as to our position when compared with the rest of the United Kingdom.

	Death Rate from Accidents per 1,000 Employed.	No. of Persons Employed per Fatal Accident.	Persons Employed per Life Lost.	Tons of Mineral per Fatal Accident.	Tons of Mineral per Life Lost.
North Staffordshire	1·258	850	795	257,148	240,558
United Kingdom	1·328	801	748	247,863	231,339

I consider that the preceding results are most satisfactory and I only hope that the improvement will continue.

I cannot close my address without referring to the opportunities given to mining students of the present day, as compared with those of 20 years ago. I remember the time when it was most difficult to obtain any book on mining subjects; and at one of the earliest examinations for the manager's certificate, out of three books suggested by the examiners for the candidates to study, one was out of print. Now, students have no difficulty in obtaining any number of good works on mining, besides having access to weekly or monthly periodicals on mining and scientific subjects.

The Staffordshire county council has taken up the work of mining

and technical instruction in a thorough manner; and when I mention the fact that Mr. Kitchener is chairman of the technical committee, with Mr. A. Sopwith as chairman of the mining committee, it will be readily understood what I mean. The mining classes arranged by them are as well divided over this wide district as possible, so that the instruction given shall be within the reach of all who are willing to avail themselves of it. Special classes in the higher branches of mining science have been arranged to be held at Stoke and Newcastle High School, and these ought to be well attended by students.

With a view to encouraging young students who are members of our Institute, I would suggest that prizes be given for the best paper on some specific subject fixed by the Council, who should appoint judges, and that the paper should be read at a special meeting of students and then discussed. I hope that the Council will see their way to arrange, say special quarterly meetings for students, at which some member of the Council could preside. If this course were adopted, I believe that it would give the students confidence to enter into discussion amongst themselves, while they would feel a little diffident in doing so at an ordinary meeting of the Institute.

I also thoroughly concur with Mr. Kitchener that technical instruction ought to begin earlier, say, in the upper standards of our day-schools; and practical and elementary technical instruction on the lines suitable for the trade of the district should be taken as a class subject. This would give the youth on leaving school a practical knowledge of the work which he is about to commence, and he would be able to intelligently understand that work, and also with greater advantage continue his studies.

I must now speak of a matter which is of the greatest importance to this district, and that is the question of a College of Science or Technical School for North Staffordshire. The members will agree that such a school is needed, and it is becoming more and more necessary every day, if we are to keep our place in the educational and commercial race of the world. At the present moment, all advanced students, after leaving school, desirous of studying the higher branches of science or taking any branch of higher technical training, have to seek that information in another district. It is absolutely necessary that all students who are expected to rise should have a scientific and technical knowledge of their profession. The youth of North Staffordshire is labouring under great disadvantages when compared with South Staffordshire, where they have Mason University College; Lancashire, possessing Owens College and the

Wigan School of Mines; Yorkshire, with mining schools at Leeds and Sheffield; and the North of England, with the Durham College of Science at Newcastle-upon-Tyne.

Is it possible that anything could be done to make a commencement towards the founding of such a college in North Staffordshire? Surely, out of a population of nearly 300,000, with the numerous employers of labour to whom such a school would be of the greatest value, something might be done! I know there is a difficulty in the way of a beginning being made owing to the fact that the various towns in the district (and I say this to their credit) have their different institutions, where a certain amount of instruction is given on various subjects to students; but what we want is a central college where advanced instruction can be given, enabling North Staffordshire to compete with other districts. If such a building could be erected, it could also be made of great usefulness to the district. I see no reason why it may not be made a home for our Institute, where our library, which is now under lock-and-key, might be used by students. The Chamber of Commerce, the Coal and Iron Masters' Association, and the Master Potters' Association might also find it a useful centre for their meetings.

I cannot but think that, considering the wealth and increasing importance of North Staffordshire, if this question were thoroughly taken up by some energetic person, who could give his time to so good a work, it would before many years become an established fact, and I feel that I am not betraying any trust when I say that the county council would be able to render substantial help.

I must congratulate the district on the amicable settlement of the wages question. In this, I feel sure, both parties have acted wisely, seeing that, for some years at least, we have had none of those unfortunate cessations of work which tend to ruin and impoverish both capital and labour, and do so much to upset our trade, and help outside competition. Strikes and lock-outs are unadvisable on the grounds of justice and common sense, and should not be tolerated by either employer or employed. Any question or grievance ought to be adjusted by some properly constituted board or court of appeal; and no body of men should be allowed to stop work pending such an enquiry. This question, I am afraid, will have to be made a national one, for while admitting the difficulties and dangers of such a course, I cannot but think that owing to the great national loss which results whenever a stoppage of production takes place, it must eventually be taken up by Parliament.

In conclusion, I must thank the members for the patience which they have extended to me while delivering this address. I hope that some of my remarks may lead to a more thoughtful consideration of the subjects referred to, and that some little benefit may result from them to our district.

Mr. JOEL SETTLE said that the desirability of establishing a mining-school for the district had been considered before, but it had failed owing to want of support. He thought that it was highly creditable to North Staffordshire that, though the mines of the district were so difficult to work, the number of accidents per 1,000 workmen employed and per ton of mineral raised was less in North Staffordshire than the average for the kingdom. He moved a vote of thanks to Mr. Cadman for his address.

Mr. R. H. COLE, in seconding the resolution, observed that this question of a mining-school seemed to be coming again to the front. They must begin in a humble way, and if they only had a small school at first, it would be a benefit to the district. He suggested that in addition to thanking Mr. Cadman for his address, they should tender to him an expression of their sympathy with him in his inability to be present.

The resolution was carried unanimously.

DISCUSSION ON MR. W. E. GARFORTH'S "SUGGESTED RULES FOR THE RECOVERY OF COAL-MINES AFTER EXPLOSIONS."*

Mr. W. N. ATKINSON said that Mr. Garforth's paper on the "Recovery of Coal-mines after Explosions," was worthy of careful consideration by everyone concerned in the management of fiery and dusty collieries. No one in such a position could read the paper without obtaining many suggestions likely to be of service in case of a serious explosion. Some of the suggested rules might, perhaps, appear to be counsels of perfection which were not likely to be fully adopted on account of the comparative rarity of large explosions, but they were

* *Trans. Inst. M.E.*, vol. xiv., page 495; vol. xv., pages 134, 210, 249, 261 and 268; and vol. xvi., page 99.

still useful as indicating requirements likely to arise when explosions did occur, and it should be borne in mind that a sweeping explosion was an occurrence possible at any time in a dry and dusty mine. Especially worthy of consideration were the means of entering the mine, in case the winding-engine and cages were rendered useless. At the explosion at Seaham colliery in 1880, 12 hours elapsed after the explosion before the mine could be entered, owing to damage in the shafts and to the winding-engine, during which time several fires, caused by the explosion, were burning in the pit. He suggested that if the roads leading to the shafts were kept free from coal-dust for a radius of 300 feet the shafts would probably altogether escape damage. Another important matter was the provision of plans or tracings showing the engineering details of the mine. Plans of mines, as kept in many districts, were generally deficient in details; they did not distinguish intake and return airways and other roads in use from roads which were abandoned and impassable, nor did they show the position of air-crossings, doors, etc. On such plans it was sometimes difficult for the manager himself to trace accurately the course of an air-current, the exact course of which it might be important to know in such an emergency as an explosion or a gob-fire. Plans which showed all the engineering details possible were of the greatest assistance to strangers who might offer their services after an accident. Mr. Garforth referred to the formation of district depôts for the storage of colliery-accident apparatus. This was a suggestion which had been made on various occasions; among others in a book on *Explosions in Coal-mines* published by his brother (Mr. J. B. Atkinson) and himself in 1886. It appeared possible that an attempt might be made to form such a depôt by the Midland Institute of Mining, Civil and Mechanical Engineers.* It had been suggested by Mr. Binns† that assistance should be given to such institutions by the companies insuring colliery-owners in connexion with the Workmen's Compensation Act. He (Mr. Atkinson) thought that suggestion was well worthy of consideration by such companies as well as by colliery-owners, because it was certain that if the pecuniary means were found to establish such life-and-property saving institutions, there would be no lack of volunteer assistance to manage and work them by the mining-engineers of the different districts.

Mr. E. B. Wain said that Mr. Garforth had contributed a valuable paper; but of course the members knew that no two colliery-explosions were exactly alike, and having regard to such suggestions as Mr. Gar-

* *Trans. Inst. M.E.*, vol. xv., page 252. † *Ibid.*, vol. xv., page 210.

forth had made, it was desirable to discuss, hypothetically, certain cases with a view to considering the course to be adopted under certain circumstances. Some members might have had experience in the re-opening of mines after explosions where the time occupied had been as many years as Mr. Garforth took weeks, and no doubt a very great deal of the time which had been taken up in re-opening mines might have been saved if some such rules as Mr. Garforth had propounded had been in operation. There was a point in connexion with the paper he should like to mention, and that was that underground fires were generally discovered near to the stables, and in this connexion it struck him that such fires were more or less preventible. If straw was never taken down a pit and moss litter was used for the bedding of horses, and if hay was taken down in the form of "chop," having been previously steamed, probably they would hear less of such accidents. There were undoubtedly many points in the paper which were well worth studying, but it might be a mistake to speak of them as "rules."

A considerable number of objects of interest were exhibited in the room, and, subsequently, the annnal dinner of the members took place.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE ODDFELLOWS' HALL, KILMARNOCK, DECEMBER 10TH, 1898.

MR. JAMES T. FORGIE, PRESIDENT, IN THE CHAIR.

The Minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected :—

MEMBER—

Mr. JOHN WILSON, Mount Vernon Station, Caledonian Railway, Glasgow.

ASSOCIATE MEMBER—

Mr. THOMAS WALDIE, 44, Constitution Street, Leith.

Mr. GEORGE L. KERR read the following paper on "Timbering and Supporting Underground Workings" :—

TIMBERING AND SUPPORTING UNDERGROUND WORKINGS.

By GEORGE L. KERR.

The subject of propping and supporting underground workings is not new to this Institute, for it was fully dealt with and discussed in 1881 in the report of the "Committee on Propping"; * also by Mr. Robert Martin in a paper on "Propping at Straiton and Pentland."† Moreover, quite recently an interesting paper on the "Strength of Pit-props," was read by Prof. H. Louis to The Institution of Mining Engineers,‡ and members will no doubt have read that paper with some interest.

Timbering.—The proper timbering of underground workings is one of the most important operations connected with mining. Nearly 50 per cent. on an average of the total number of accidents that take place underground are due to falls of roof and sides, and while the accidents due to other causes are diminishing to a large extent every year, those due to falls seem to remain almost stationary. For the years 1886 to 1896, the number of fatal accidents from falls of roof and sides was 4,868, the total number of fatal accidents for these years being 11,275, giving an average of 43·1 per cent. due to falls of roof and sides. Table I. shows the ratio of accidents for the several years due to these causes.

Table I.—Accidents from Falls of Roof and Sides in Coal-mines.§

Year.	Fatal Accidents due to Falls of Roof and Sides.	Total Number of Fatal Accidents.	Percentage of Accidents due to Falls of Roof and Sides.
1886	461	953	48·3
1887	470	995	47·2
1888	471	888	53·0
1889	465	1,064	43·7
1890	434	1,160	37·4
1891	476	979	49·0
1892	435	982	44·2
1893	412	1,060	38·8
1894	444	1,127	39·3
1895	426	1,042	40·8
1896	424	1,025	41·3

* "Report by Deputation on Methods of Supporting the Roof and Sides," *Trans. Min. Inst. Scot.*, vol. iii., page 51. † *Ibid.* vol. xii., page 58.

‡ *Trans. Inst. M.E.*, vol. xv., page 343.

§ *The Colliery Manager's Pocket Book*, 1898, page 71.

It will be seen from Table I. that the number of fatal accidents due to falls of roofs has decreased very little, although the ratio to other accidents is somewhat less. If we analyse the accidents taking place in each of the inspection districts it will show even more clearly how stationary is the number of fatal accidents due to falls from year to year. Table II. shows this approximately.

It will be seen from Table II. that the average percentage of accidents due to falls of roof and sides is very much alike in each of the mines inspection districts, but if we take the ratio of accidents to the number of tons of coal raised in each district, there is a very wide margin of difference, for which it is difficult to account; in part it may be due to the method of working, the nature of the roof, the depth from the surface, and the system of timbering adopted. Compared in this way, the two districts into which Scotland is divided contrast very favourably with the other districts of Great Britain. Table III. gives the details for the years 1886 to 1896.

It is a melancholy fact that a large number of accidents arising from falls of roof and sides, are due to direct carelessness of the men who are injured, through paying too little heed to the proper timbering of their working-places. It is all the more painful too, that many of these accidents happen to men who are known as good, reliable and skilful, but over confident workmen, who often rely too much on their own judgment as to where a prop is required, instead of propping their places in a regular methodical manner, and until some such system is adopted and enforced in most collieries the number of accidents from falls cannot be expected to decrease.

The principle to be recognized in timbering generally is, "that timbering is not only for a bad roof, it is also intended to prevent a good roof from becoming bad." A bad roof is often defined as one which requires some systematic method of supporting it, while a good roof is supposed to require no such methodical treatment. The roof may be bad in itself by reason of inadequate cohesion in its particles; it would then be called tender. What may generally be called a good strong roof, so far as the material of which it is composed is concerned, may be full of "lipes" and "faults" which would cause it to form a very treacherous roof. The difficulty or otherwise of keeping a roof will depend a great deal on the direction in which the roadways are driven; *i.e.*, as to whether the roads and faces are kept at right angles to the cleavage in the roof or parallel with it. Mr. A. R. Sawyer says:—

It is fallacious to suppose that what are called bad roofs need be productive of

TABLE II.—SHOWING PERCENTAGE OF PERSONS KILLED BY FALLS OF ROOF AND SIDES TO THE TOTAL NUMBER OF FATAL ACCIDENTS IN THE DIFFERENT MINES INSPECTION DISTRICTS.

Mines Inspection District.	Years.												Average after Deduction of Abnormal Causes.
	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	Average.	
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
East Scotland ...	53·4	a15·7	51·2	b26·0	45·2	48·7	51·5	50·0	55·7	45·9	48·1	44·6	48·8
West Scotland ...	68·5	62·9	47·2	43·4	38·4	57·9	46·5	42·2	38·7	c29·4	56·3	48·3	48·8
Newcastle	53·5	42·0	d31·5	46·6	32·6	41·5	50·7	52·8	47·4	35·1	50·0	43·9	45·4
Durham	45·0	45·1	52·8	50·0	56·7	52·2	59·2	48·7	44·9	47·0	e33·3	48·6	49·3
Yorkshire	42·7	66·6	60·2	52·8	47·0	42·4	54·2	f16·9	56·0	42·8	g26·7	46·2	50·7
Manchester	36·2	65·3	60·4	64·5	48·2	59·3	55·3	45·0	64·6	44·9	51·0	54·0	54·0
Liverpool	56·3	62·2	55·3	h48·2	61·8	56·5	i43·0	54·6	59·7	57·0	59·7	55·8	57·5
Midland	60·3	52·9	62·2	50·0	49·2	58·3	57·5	41·9	65·3	34·4	51·6	53·0	53·0
North Staffordshire	46·6	46·8	56·4	j12·3	46·5	k38·1	59·3	43·9	51·8	l13·9	43·1	41·7	47·3
South Staffordshire	66·6	30·0	52·9	54·3	50·0	69·2	38·8	34·1	42·0	58·8	53·8	49·1	49·1
South-western ...	33·7	62·9	52·7	53·8	m13·0	n41·2	46·4	50·0	53·0	47·8	59·1	46·6	50·8
South Wales ...	51·5	o47·7	55·5	50·3	p32·6	39·4	q29·1	r36·6	s18·6	45·0	t31·4	39·8	49·3

(a) Explosion at Udston colliery, being excluded, would give 30·3 per cent. (b) Underground fire at Mauricewood colliery, would give 57·7 per cent. (c) Explosion at Quarter colliery, Denny, would give 35·3 per cent. (d) Explosion at St. Helen's colliery, would give 47·5 per cent. (e) Explosion at Brancepeth colliery, would give 41·4 per cent. (f) Explosion at Combs colliery, would give 46·8 per cent. (g) Explosion at Micklefield colliery, would give 46·9 per cent. (h) Explosion at Brynmally colliery, would give 58·5 per cent. (i) Underground fire at Bamfurlong colliery, would give 51·9 per cent. (j) Explosions at Hyde and Mossfields collieries, would give 37·2 per cent. (k) Explosion at Apedale colliery, would give 46·6 per cent. (l) Inundation at Audley colliery, would give 42·1 per cent. (m) Explosion at Llanerch colliery, would give 50·8 per cent. (n) Explosion at Malago Vale colliery, would give 49 per cent. (o) Explosion at National colliery, would give 59·4 per cent. (p) Explosion at Morfa colliery, would give 50·9 per cent. (q) Explosion at Park Slip colliery, would give 46·3 per cent. (r) Underground fire at Great Western colliery, would give 50·6 per cent. (s) Explosion at Albion colliery, would give 56·5 per cent. (t) Explosion at Tylorstown colliery, would give 40·7 per cent.

TABLE. III.—SHOWING THE NUMBER OF TONS OF MINERALS RAISED PER FATAL ACCIDENT DUE TO FALLS OF ROOF AND SIDES.

Mines Inspection District.	Years.										
	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1896.	1897.
	Tons.	Tons.	Tons.	Tons.	To	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
East Scotland	536,395	714,002	448,024	539,337	510,996	481,309	535,614	557,185	372,152	474,713	580,996
West Scotland ...	308,808	441,171	452,768	533,404	562,971	352,807	464,582	610,425	531,586	592,189	440,587
Newcastle	557,746	536,427	628,358	548,915	654,370	615,759	489,978	430,825	582,094	769,450	563,109
Durham	571,484	623,998	578,317	634,235	740,289	584,539	642,362	685,380	705,482	688,134	856,090
Yorkshire	353,894	277,647	395,405	401,031	475,409	544,490	525,858	442,792	428,031	597,938	630,431
Manchester	208,185	293,713	353,790	261,776	386,645	290,912	344,768	289,211	326,030	334,632	436,539
Liverpool	254,190	245,771	267,292	261,775	266,591	251,945	373,672	258,432	367,975	331,236	335,053
Midland	443,534	480,879	478,965	620,185	645,619	620,391	517,288	618,491	643,842	1,030,662	703,218
North Staffordshire ...	556,351	478,746	361,731	462,540	380,988	365,505	392,903	393,718	526,760	439,380	385,111
South Staffordshire ...	320,983	622,790	372,755	418,256	506,515	390,396	741,526	645,602	451,254	358,125	450,861
South-western ...	346,797	287,221	343,812	284,942	329,803	398,114	392,309	334,214	432,854	320,088	412,152
South Wales	211,238	199,504	229,101	187,598	277,080	284,591	265,898	266,920	299,250	285,813	307,646

more accidents than good roofs. Roofs containing numerous dislocations, lying much in the same direction, necessitate a specially systematic kind of timbering, which will ensure comparative safety; while a good roof, in which dislocations occur rarely, but unexpectedly, may be fraught with danger from the want of a rigid system of timbering, irrespective of whether in individual places posts are absolutely required or not.*

Timbering may be divided into two distinct heads, namely:—(1) Timbering the working-faces, and (2) timbering the drawing and main roads. The timbering or supporting the roof may be done in a variety of ways, according to the nature of the roof, floor and sides, and may be classified as follows:—(*a*) By packing the waste entirely, where sufficient rubbish can be got, and timbering at the face and roads, as in longwall. (*b*) By partial packing of the waste, by buildings or stone pillars, with intervening spaces, and timbering in the face and roads. (*c*) By timbering at the face and in the roads, and leaving wooden or stone pillars in the waste as supports. This is usual where no packing-material can be obtained from the seam. (*d*) By timbering alone, without any packing whatever, as in bord-and-pillar or in working longwall on the retreating system. (*e*) Supporting the main roads with brick arching, steel or iron; or masonry and steel or iron combined.

The different kinds of wood used for mine-timbering in Great Britain are larch, Scotch fir, Norwegian pine, and sometimes oak and beech. For ordinary timbering, Scotch fir is largely used, especially where the timber does not require to be heavy, and where the pressure is not great; but in drawing and main roads that have to be kept open for some time larch has been found to be most efficient, both as regards durability and economy. Any woods that are long grained and elastic, and will yield to thrust are suitable for mine timber, because props of such woods often serve the purpose for which they are used, even when partially fractured.

Beech or oak props are short grained, more or less brittle, and break off short under crushing-strain. Their great weight, as compared with other woods, and the consequent difficulty in handling them, is against their use underground.

In timbering at the face, single props are usually set with a lid or bonnet on the top next the roof. The lid prevents the weight from coming on the props suddenly and fracturing them; it also gives additional crushing-strength to the prop, and spreads the pressure over a larger area. Figs. 1, 2 and 3, and 4 and 5 (Plate VII.) show some of the different methods of setting props at the working-face. When the

* *Accidents in Mines*, 1886, by Mr. A. R. Sawyer, page 28.

pavement is hard and slippery, the props are often pointed, so that they will crush up when the pressure comes on them.

Wooden chocks or pillars are also used for supporting the roof at the working-face and in the main roads. These are composed of either round or square pieces of timber from 3 to 6 feet long, laid lengthwise and across each other, and the open spaces are filled with rubbish (Figs. 6 and 7, Plate VII.).

In setting props at the working-face it is not usual to set them at right angles to the inclination of the seam, except in flat seams, but the greater the inclination of the seam the more the props should be set off the perpendicular or underset.

The props when set should lie towards the rise of the seam, so as to secure the best results. They must not, however, be too much underset, as in such circumstances, the props give less resistance to the roof, and they also require to be longer and consequently weaker. The amount of underset or of inclination given to the props ought to vary with the rate of dip, and props set with the same inclination in a steep seam, as in a comparatively flat one, would be apt to fall out before the pressure of the roof had tightened them.

Table IV. show the maximum and minimum angles at which props should be set in varying inclinations, and is extracted from Mr. A. R. Sawyer's *Accidents in Mines.** This table allows for a liberal margin for practical difficulties in setting, and the angles given should not be exceeded.

TABLE IV.—UNDERSETTING OF PROPS.

Rate of Inclination of Seam. Degrees.	Angle or Underset of Props. Minimum. Degrees.	Maximum. Degrees.
6	0	1
12	0	2
18	1	3
24	1	4
30	2	5
36	2	6
42	2	7
48	3	8
54 and upwards	3	9

Timbering the roadways is done in a variety of ways according to the nature of the roof, floor and sides. When the roof alone requires support, and the sides are hard and firm, a cross-bar will be sufficient without being supported by props. The cross-bar is fixed by needling it into holes made in the sides for it to rest upon, as shown in Figs. 8 and 9 (Plate VII.). Sometimes the bar rests on a prop at one end and is

* Page 50.

needled in at the other end as shown in Fig. 10 (Plate VII.). When the sides cannot be depended on to support the cross-bar, a common arrangement is to put up a cross-bar or crown (either round or half-round) and support it at each end by a prop set at a slight angle towards the centre of the road, so as to decrease the span and strengthen the crowntree (Fig. 11, Plate VII.). In this method, no preparation is made in the timber beyond cutting it to the required length.

When heavy side and roof-pressure has to be dealt with, various methods are used in which the timber is cut or notched in a special manner. Figs. 12, 13, 14, 15 and 16 (Plate VII.) show the different notches that are used, that shown in Fig. 15 being possibly the best method. The Welsh system of timbering is much used under such circumstances, and is found to give good results when properly put up, the sides being supported with side-lagging of either square or round pieces of timber placed longitudinally behind the props (Fig. 17, Plate VII.). The advantages claimed for the Welsh system are:—(1) Less cost than ordinary timber, as shorter crowns are used, and (2) greater resistance to heavy side-pressure. On the other hand, the increased cost of preparing and setting the props must be taken into account. In Wales, where this method is much used, the men are paid 1s. 9d. to 2s. 6d. per set for erection.

When the roof and floor are bad, it is difficult to keep the roads in good condition with ordinary timbering, and to prevent the floor from rising sill-pieces are often used, and the props or legs are notched into them as well as into the crowns (Fig. 18, Plate VII.). The sill-pieces, however, have their disadvantages where the floor is given to heaving; and when the road requires adjusting, as it frequently does under such circumstances, the sill-pieces give trouble and often create the danger that they were meant to avoid.

In some of the mines of California, where heaving of the floor causes great trouble, a novel and peculiar method of timbering was adopted. A drift of the usual form was cut and heavily timbered, being well lagged over-head, the sets of timber being placed 5 feet from centre to centre. As the driving of the drift proceeded, a triangular section was cut out of each side of the drift between the posts of two adjoining sets. These two posts formed the base of a triangle, the apex being placed directly opposite the centre of the base, or opposite half of the distance between the posts. At the apex, a post was set, the centre of which was 3 feet from the centre-line of the posts forming the base. Caps were placed reaching from the post at the apex to each of those of the base,

and lagging was driven in diagonally from the drift. The two sides of the triangular section opposite the base were lagged, a considerable space being left between the lagging-boards so as to afford an opportunity for the soft swelling ground to force its way through the open spaces, whence it was removed. These triangular spaces were continuous, *i.e.*, were cut opposite each set of the main drift. Figs. 19 and 20 (Plate VII.) show this peculiar method of timbering. This method involved considerable extra expense in mining and timbering, but it was superior to any plan previously tried, and was a success both mechanically and financially.

Square Sets.—In metalliferous mines, veins of great width have often to be worked, and the greatest difficulty is often met with in supporting the side walls or hanging-wall, especially when the pressure is great, as in veins being worked at considerable depths from the surface. On the celebrated Comstock lode, Nevada, U.S.A., where the ore occurs in great bodies, one *bonanza* measured 340 feet in width at one point, 600 feet in height, and 1,250 feet in length. It would be absolutely impossible to extract such great masses of mineral and support the excavations by ordinary methods of timbering. It was here (Comstock lode) that the "square method" of supporting excavations was first invented by Mr. Philip Deidesheimer, and used at the Ophir mine with great success. Square sets are constructed principally of three pieces, viz., post, cap, and strut, and in addition for the foundation sets, sill-pieces are required. These sill-pieces, which are 16 to 20 feet long, are first laid down on the floor at right angles to the wall. Along these sill-pieces, at regular intervals, are cut shallow notches about 1 inch deep, and large enough to suit the posts which rest upon and are fitted into them. In the centre of the sill-piece, a mortice is cut about two-thirds the area of the end of the post, and into this mortice a tenon, which is formed on the bottom of the post, fits exactly. The sills are laid horizontal and parallel, being placed about 6 feet between centres. Two sill-pieces having been laid down, four posts, one at each end of the sills, are placed in position, this constituting the four corners of a set. On the top of the posts, a temporary platform is erected, by fixing planks to the two sets of posts, and placing across these planks other pieces of lagging. This platform is necessary to enable the men to lift the heavy caps and place their ends upon the posts. The caps are placed directly above and parallel with the sill-pieces. Each post is cut with a tenon at top and bottom. The method of fixing them will be

understood from the drawings (Figs. 33, 34 and 35, Plate VIII.). In the succeeding sets, the posts are set vertically above each other, and all the timbers carefully framed so as to fit properly at the joints. Tie-pieces are also fitted on to the top of the posts and at right angles to the caps, the ties being often secured tightly by wedges. The sizes of timber used in square sets may vary from 8 to 24 inches square; the smaller the timber, the greater number of pieces will require to be used in each set to give the required strength to resist the pressure.*

At the Utica gold-mine, California, where a valuable gold-bearing rock is found, and where large excavations have also to be supported, a method of timbering somewhat similar to square sets is carried out, but circular timber is used instead of square pieces. The timber used is generally 18 inches in diameter and over. The posts are cut to 14 inches square at the top and bottom, and a tenon formed 4 inches in height; the caps being cut to the same dimensions, with a tenon 6 inches long. When the caps and posts are fitted on to each other, the tenons do not meet, a space of 2 inches separating them. Into this space a wooden wedge 2 inches thick and 14 inches wide is driven to fill up the space. At the junction of the cap and post, two tie-pieces are used instead of one as in the square sets, the tie-pieces being 12 to 16 inches in diameter by 4 feet long. This method of timbering involves more dressing and fitting than the square set system, and possesses no advantages over that method, except it be that round timber is sometimes more easily got than square sawn pieces. The method of fixing the timbers is shown in Figs. 36 and 37 (Plate VIII.).†

When the roof is heavy with no bed of hard rock in it, and the roads have to be driven comparatively wide, such as in pony-roads, and where roads branch off each other, it is often very difficult to properly support such places. In such circumstances only good heavy larch-timber ought to be used for crown-pieces and props. A method of supporting such wide places is shown in Figs. 21 and 22 (Plate VII.). Crown-trees are set, and temporary supports placed in the centre of the crown-trees. Other crown-trees are placed at right angles to these or parallel with the road, along the ends of the cross-bars, and to those crown-trees parallel with the road the props are set, and all firmly fixed with wedges and lofting. Where roads branch off or cross each other, diagonal sets are sometimes erected to assist the cross-sets.

* *Monographs of the United States Geological Survey*, vol. iv., page 89. *California State Mining Bureau, Bulletin No. 2*, "Methods of Mine-timbering," 1894, page 39; and 1896, page 46.

† *California State Mining Bureau, Bulletin No. 2*, "Methods of Mine-timbering," 1894, page 51; and 1896, page 62.

If the road be very wide, and two lines of rails are laid, it is a common practice to erect centre props as well as end ones, but this method should be avoided as much as possible, especially where there is much traffic on the roads, as they may become a source of danger. On the Continent of Europe, a method of supporting the cross-bar by means of auxiliary centre supports tapering from the side posts is carried out, and is found to give satisfactory results. Short props (*a*) are set alongside the main props, and on these, other pieces (*b*) are laid longitudinally, and from these longitudinal pieces other posts (*c*) are set at an angle so as to meet in the centre of the cross-bars where another bar (*d*) is fixed parallel with the road (Fig. 23, Plate VII.). This method has the disadvantage that on a wide road it could not be properly used as the space would be so much curtailed. To overcome this difficulty, the method shown in Fig. 23 (Plate VII.) is adopted and found to answer the purpose intended. None of these methods is used to any extent in this country, and it is questionable if it would not be cheaper to build side walls and use iron or steel girders under such circumstances.

Cost of Timber.—The cost of timber varies in different districts and in different collieries, and may cost anything between ½d. to 9d. per ton of coal raised, according to the depth from the surface, the thickness of the seam, the nature of the roof, the inclination of the seam, and the method of working. Table V. shows the approximate cost of timbering in several mining districts in Great Britain.

TABLE V.—SHOWING COST OF TIMBER PER TON OF COAL RAISED.

No. of Colliery.	Thickness of Seam.	Depth from Surface.	Nature of Roof.	Inclination of Seam.	Method of Working.	Cost per Ton.
	Feet.	Feet.				Pence.
1	2½ to 3¼	1,000	Fairly good	Comparatively flat	Longwall	3
2	2 to 4	1,050	,,	—	,,	2¾
3	2 to 5	1,100	Soft roof	—	,,	4
4	1½ to 1¾	1,550	Bad roof	1 : 5, and upwards	,,	8½
5	2½ to 4	100 to 250	Fairly good	Flat, to 1 : 15	Longwall and pillar-and-stall	2¾
6	5½	1,050	Soft shale	1 : 9	Double-stall	8
7	6¼	850	,,	Flat, to 1 : 14	Longwall	5
8	5¼	1,200	Shale	1 : 20	,,	2½
9	7	1,700	Good roof	Flat	Pillar-and-stall	1¾
10	5¾	1,600	,,	1 : 6 to 1 : 18	,,	2⅓
11	6½	600	Bad roof	1 : 20	Longwall	3½
12	5	1,800	Good roof	1 : 12	,,	1
13	5	1,200	Fairly good	—	,,	2
14	4	1,150	Good roof	1 : 6	,,	½

Steel and Iron Supports.—Within recent years the use of iron and steel supports for underground roads has greatly extended, and under certain conditions their use may be recommended. But it must be remembered that the conditions under which steel or iron girders can be used underground are different from the conditions under which the same materials are used on the surface. When used on the surface, all the conditions that will affect the supports in any way can be accurately determined, and the size and strength of support to be used for any purpose can be ascertained by calculation. Underground, these conditions can hardly be ascertained at all, or at least only very partially; the top weight to be supported may be unknown, and further complications are introduced when heavy side-pressure is encountered. Instead of the load being uniform, as on the surface, it is very varied, and the supports are subject to great and sudden pressure. Steel girders, however, seldom break under sudden pressure or weight, and nearly always give indications of pressure by deflecting in the centre. Girders have been known to show 5 to 7 inches of deflection before breaking.

In a large number of mines there are main haulage-roads and horse-roads where the strata have settled, and where the pressure is fairly uniform and constant. In such roads, steel or iron supports can be used to advantage. Again, in return air-ways, where the air is hot and foul, wood very rapidly deteriorates and requires frequent renewal, and in such circumstances steel or iron supports may be advantageously used.

On the Continent of Europe, a simple arrangement is used, as shown in Fig. 25 (Plate VII.). Iron bars, weighing 8 to 10 pounds per foot and shaped like girders, are bent in the form of a horse-shoe to suit the roadway, and are set up 2 to 3 feet apart. The space between the webs is filled up with planking 1½ to 2 inches thick, forming a neat and strong lining.

Another method, adopted in the North of France, is to use the girder in two pieces curved at the top, joined by two fish-plates in the centre, and fastened by four bolts (Fig. 26, Plate VII.). A cast-iron sleeve may be used in place of the fish-plates, and old iron rails may be used as girders. When the pavement is soft and liable to creep, the support is made in three pieces bent to fit the road-way and joined to one another in the same way as before, with fish-plates and bolts or by an iron sleeve and wedges (Figs. 27 and 28, Plate VII.).

In using girders and steel props, one great difficulty is to prevent them from canting. To overcome this difficulty, the supporting props may be made hollow, and fitted with flanges somewhat like cast-iron

Fig.

Fig. 8.—Elevation.

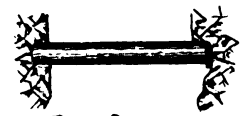

Fig. 9.—Plan.

Fig. 17.

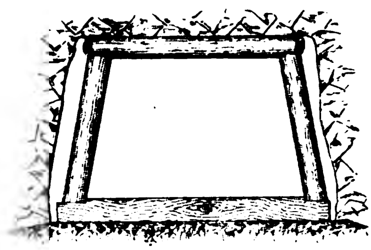

Fig. 18.

.B. of Fig. 20.

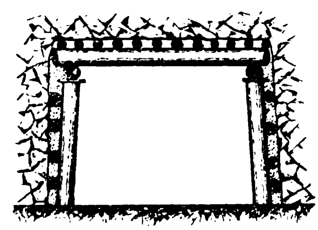

Fig. 21.—End Elevation.

Fi Fig. 24.

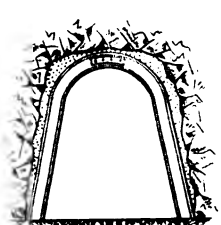

Fig. 25.

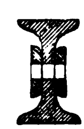

Fig. 26.

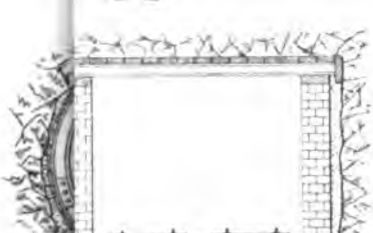

Fig. 31.—End Elevation.

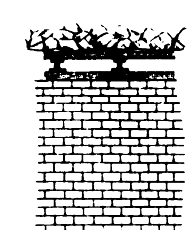

Fig. 32.—Side Elevation.

To illustrate Mr G. L. Kerr's Paper on "Timbering," &c.

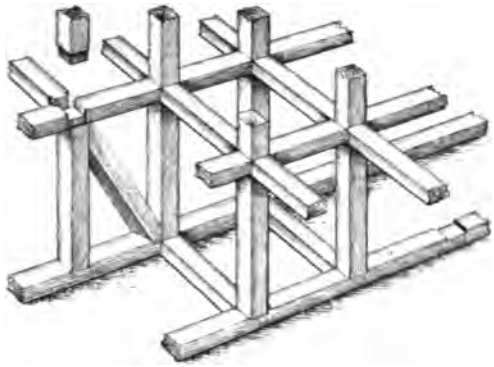

Fig. 33.

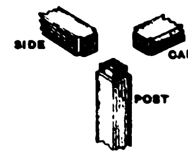

Fig. 34.

Fig. 35.—Plan.

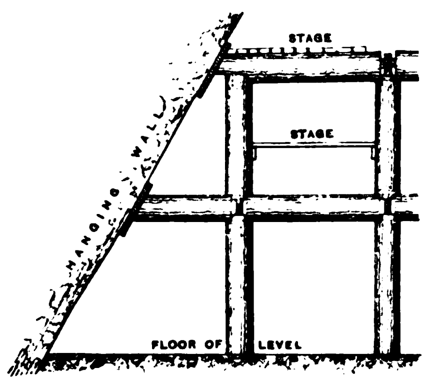

Fig. 36.—Cross Section.

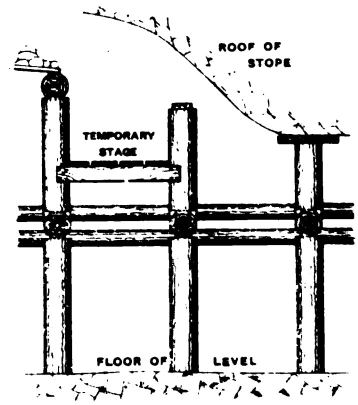

Fig. 37—Longitudinal Section.

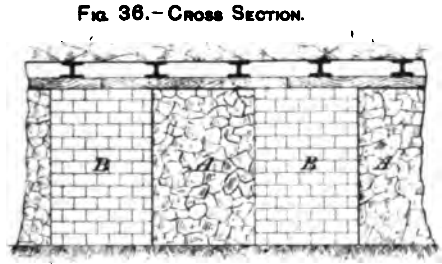

Fig. 38.—Longitudinal Section.

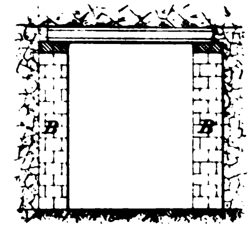

Fig. 39.—Cross Section.

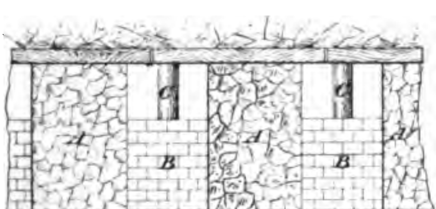

Fig. 40.—Longitudinal Section.

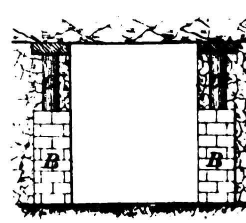

Fig. 41.—Cross Section.

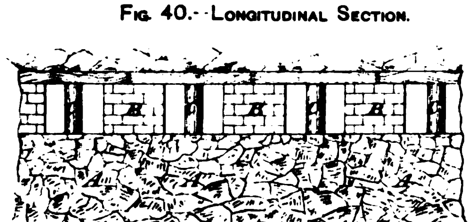

Fig. 42.—Longitudinal Section.

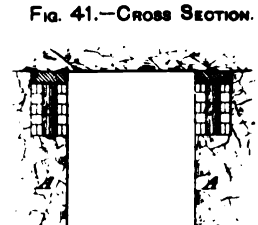

Fig. 43.—Cross Section.

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pipes. Into the top of these hollow props a chair is fitted, and receives a reversed cast-iron rail weighing about 16 lbs. per foot (Fig. 29, Plate VII.). The sets (Fig. 30, Plate VII.) are placed 3 feet apart, well lagged on the top with planking, and all empty spaces are tightly packed with rubbish. This method is best suited for a weak roof and no side-pressure. The cost is about 15s. per foot.

Brickwalls and Girders.—Main haulage-roads and shaft-bottoms are often secured by building up a perpendicular brickwall, 14 to 24 inches thick on each side of the road, and stretching steel girders across them (Figs. 31 and 32, Plate VII.). Along the top of the wall, wooden planking is laid, on which the girders are rested. The wood helps to relieve any sudden pressure that may come on the iron girders. The girders should be wedged tight, and a runner or strap of iron should be fixed between the set so as to prevent them from canting. On the top, lagging of square or round pieces of timber are laid close together and all spaces carefully packed.

At Milnwood colliery, Bellshill, wooden lagging was replaced by iron straps, about 3 inches broad and $\frac{5}{8}$ or $\frac{3}{4}$ inches thick placed close together. This system is preferable to that of using wooden lagging, as the wood decays and requires frequent renewal.

At Bent colliery, Hamilton, iron rails supported by brickwalls (14 inches thick) were used to protect the pit-bottom, and have given satisfaction.

At Lanemark colliery, New Cumnock, side-walls are built on each side of the road with the rubbish got in the workings, using cement, mixed with sand, in the proportion of 1 part of cement to 4 parts of sand, to bind the stones together. At intervals along the road, brick pillars are built up to the same height as the stone building. Along the top of the side-walls a wooden plank is laid, and on top of them light steel girders are used to support the roof. Figs. 38 and 39 (Plate VIII.) show this method, *A* being the stone and cement building and *B* the brick pillars. Another method is shown in Figs. 40 and 41 (Plate VIII.) in which stone and cement are built up to within 4 inches or so of the roof, and into this space a longitudinal piece of wood is laid and wedged tight to the roof. Between the stone pillars a pillar of brick *B* is built halfway up, and upon the top of this a short prop *C* is fixed between the pillar and the longitudinal planking. Another variation of this system of supporting the roadways is shown in Figs. 42 and 43 (Plate VIII.) in which a continuous wall of stone and cement

A is built up to about three-fourths the height of the road, and on the top of this building short pillars of brick *B* and short props *C* are carried up to support the longitudinal pieces of wood. In both of the latter methods no cross supports are used, the roof not requiring it. In other parts of the working, the walls are entirely built of rubbish got from the workings and cemented. This kind of wall is found to give better results in many cases than brick and lime in resisting pressure, the walls often deflecting to a considerable amount before giving way. By these systems of supporting the roads, a small quantity of bricks are required, and it can be built very cheaply, ordinary workmen being able to put up the stone buildings. In stoop-and-room working, it also prevents slabs of coal from breaking off the stoops and falling over on to the roadways, which often causes inconvenience in such workings, especially on main drawing-roads, where much expense is often incurred in keeping them free from falling coal and sometimes of falling roof consequent on the diminished support which the stoops provide.

The advantages of using this method of support instead of brick-arching are: (1) Less space is required to be excavated for a given area, being nearly 25 per cent. less than for brick-arching; (2) less time is required for erection, and hence less cost for labour; (3) where the strata are soft, girders can be placed as the work proceeds; while with brick-arching temporary supports would have to be used, thus increasing the cost; and (4) increased space for ventilation (8 to 10 per cent. more).

The cost of iron or steel girders will depend on the fluctuating price of the material and the proximity or otherwise of the colliery to the source of production. At present (1898), the cost of girders is about £5 10s. per ton, and for the various sections of 16⅔, 22 and 24 lbs. per foot, runs about 9d., 1s. and 1s. 1d. per foot respectively. Compared with the price of timber, the cost is very little in excess of larch props; and if the cost of trimming and allowance for waste be added, it may be found that the cost of girders is less per foot than timber. A bar of timber, 9 inches in diameter and 9 feet long, contains 5 cubic feet, weighs when dry 19 lbs. per foot, and this at 1s. 3d. per cubic foot would cost 6s. 3d. per bar, while a steel girder 9 feet long and weighing 16⅔ lbs. per foot would cost 6s. 9d.

Owing to the varying conditions of different mines, it is impossible to fix any definite weight or size of girder for a given span. Sometimes a 9 feet girder (8 feet span) of 5 inches by 4 inches by ⅜ inch section is

used instead of larch timber, 9 inches in diameter.* Under comparatively equal loads, the various weights, etc., of girders are shown in Table VI.

TABLE VI.†

Depth of Girder.	Width of Flange.	Thickness of Web.	Weight per Foot.	Estimated Safe Dead Distributed Load for 8 Feet Span.
Inches.	Inches.	Inches.	Pounds.	Tons.
5	4	$\frac{3}{8}$	$16\frac{2}{3}$	7
5	4	$\frac{1}{2}$	22	9
6	$4\frac{1}{2}$	$\frac{1}{2}$	24	12

The following weights of girders are often used for spans of 6 to 14 feet. Girders weighing $16\frac{2}{3}$ lbs. per foot, for spans of 6 to 8 feet; 22 pounds per foot, for spans of 8 to 10 feet; and 24 pounds per foot, for spans of 10 to 14 feet. These can only be taken as approximate sizes, and it would be best to err a little on the safe side.

Some of the advantages claimed for iron and steel girders over timber or brick-work are:—(1) They are lighter and handier to work with than heavy wooden beams; (2) iron-work can be erected in about one-fourth less time than brick-work, and hence fewer men are required for a given amount of work; (3) girders can easily be removed from one part of a mine to another and be reset, whereas brick-work is seldom removed; (4) girders give an increased space for ventilation compared with timber; (5) greater durability, which means a reduction in cost for repairs; and (6) no pollution of air, as is the case with decaying timber, and there is no risk of girders catching fire.

Strength of Timber.—The strength of timber is not easily determined, and no rules can be given as to the size of props or crown-trees to be used underground. Everyday experience in practical working seems about the safest and best rule to depend on at present.

Prof. H. Louis stated that "the strength of a pit-prop is practically independent of its length, within ordinary limits."‡ The statement as to the strength of props appears to the writer scarcely correct either in theory or practice. As the law as given by numerous experiments on the subject of the strength of pillars of timber is that "the strength of pillars of timber is inversely proportional to the square of the length;" thus, with the lengths in the ratio of 2, 4 and 8 feet the strengths are

* *Trans. Inst. M.E.*, vol. x., page 274. † *Ibid.*, page 273.

‡ *Ibid.*, vol. xv., page 352.

in the ratio of $(\frac{1}{2})^2$, $(\frac{1}{4})^2$ and $(\frac{1}{8})^2$, or $\frac{1}{4}$, $\frac{1}{16}$ and $\frac{1}{64}$. Thus, taking pillars of the same sectional area, one 2 feet long has 16 times the strength of one 8 feet long and 4 times that of one 4 feet long. This is wellknown in everyday practice, and no colliery manager would use props of the same diameter for workings of heights of 2 and 8 feet respectively, but he would increase the diameter of the prop according as the height of working increased.

For ordinary larch props the crushing strain is about 1½ to 2 tons per square inch, according to the age of the wood and the seasoning that it has undergone.* If timber be cut when green, and allowed to season or dry in a gradual manner, it is found to be more durable, as proved by the experiments carried out by Prof. Louis, where he records an increase of 49 per cent. in strength, due to seasoning of ordinary pit-props. The same conclusions and results were arrived at after a number of tests, which were recently carried out by the government colliery-officials in the Saar district of Germany. These tests were made on four different kinds of wood, as shown in Table VII.†

TABLE VII.

Kind of Timber.	Wood shortly after Felling.		Wood 5 Months after Felling.		Kind of Timber.	Props Artificially Dried in a Temperature of 149° Fahr.	
	Resistance to Compression.	Specific Gravity.	Resistance to Compression.	Specific Gravity.		Resistance to Compression.	Specific Gravity.
	Lbs. per Sq. Inch.		Lbs. per Sq. Inch.			Lbs. per Sq. Inch.	
Beech, with bark ...	3,243	1·084	3,570	1·094	Beech, without bark ...	3,627	0·915
Fir do. ...	2,802	0·885	3,044	0·845	Fir do. ...	3,385	0·656
Pine do. ...	2,631	0·984	2,716	0·917	Pine do. ...	2,958	0·647
Oak do. ...	2,475	1·235	2,133	1·050	Oak do. ...	2,958	0·825

The strength of timber varying so greatly, as given by different authorities, makes it very difficult to form any rule for guidance, even where the weight or pressure is definitely known.

Table VIII. shows the crushing-strains of different woods.

It will be seen that the crushing-strength, as given by Mr. Box, is somewhat different from that in the tables quoted, and also the crushing-strain as determined by Prof. Louis. The differences may, of course, be accounted for by the different specimens tested, those in most tests being special pieces, free from blemishes, and having no resemblance to pit-props.

* *Trans. Inst. M.E.*, vol. xv., page 352.

† "Ueber die Gebrauchsfähigkeit einiger Holzarten zum Grubenausbau," by Berginspektor Ch. Dütting, *Glückauf*, 1898, vol. xxxiv., page 797.

TABLE VIII.—STRENGTH OF TIMBER TO RESIST CRUSHING-STRAINS IN POUNDS AND TONS PER SQUARE INCH.*

Kind of Timber.	Maximum Dry.	Minimum Ordinary State.	Mean.	
	Pounds.	Pounds.	Pounds.	Tons.
Ash	9,363	8,683	9,023	4·03
Beech	9,363	7,733	8,548	3·81
Birch (English) ...	6,402	3,297	4,850	2·16
Elm	10,331	7,950	9,140	4·08
Fir (spruce) ...	6,819	6,499	6,659	2·97
Oak (English) ...	10,058	6,484	8,271	3·69
,, (Quebec) ..	5,982	4,231	5,106	2·28
Pine (pitch) ...	6,790	6,790	6,790	3·03
,, (red)	7,518	5,395	6,457	2·88
Larch	5,568	3,201	4,385	1·96

TABLE IX.—SHOWING STRENGTH OF TIMBER PER SQUARE INCH TO RESIST TENSILE STRAIN.†

Kind of Timber.	Maximum.	Minimum.	Mean.	
	Pounds.	Pounds.	Pounds.	Tons.
Ash	17,850	15,784	17,077	7·6
Beech	11,626	11,388	11,467	5·1
Birch	—	—	15,000	6·7
Elm	—	—	13,490	6·0
Fir	13,448	11,000	12.203	5·5
Oak (English) ...	15,500	13,620	14,560	6·5
Pine (Russian) ...	—	—	13,300	5·9
,, (Norway) ...	14,300	12,400	13,350	6·0
Larch	—	—	9,632	4·3

TABLE X.—SHOWING SPECIFIC GRAVITY AND WEIGHT OF MATERIALS (WATER AT 62° FAHR. BEING EQUAL TO UNITY).

Material.	Specific Gravity.	Weight of 1 Cubic Foot.	Measurement of 1 Ton.
		Pounds.	Cubic Feet.
Wrought-iron ...	7·788	485·30	4·615
Cast-iron (British) ...	7·087	441·60	5·070
Oak (seasoned) ..	0·777	48·42	46·260
Elm	0·588	36·65	61·130
Pine (yellow), seasoned	0·483	30·10	74·410

Preservation of Timber.—Timber required for use underground, or indeed anywhere, should be cut in winter, when the wood has little sap in it, because the sap ferments and causes rapid decay; wood should also be well seasoned before being used; and if these two points are carefully attended to they constitute frequently the only preservative that the

* *A Practical Treatise on the Strength of Materials*, by Mr. Thomas Box, 1883, page 91. † *Ibid.*, page 4.

timber requires. The bark should also be removed before being used underground; and if this be done there is less liability for the timber to rot, and the decay, when it sets in, is more easily detected.

Various methods of preventing dry rot of timber in mines have been tried: good ventilation being necessary, as timber decays more rapidly in hot, foul air. Water is a good preservative, and the writer has known mines where the shaft-timber was kept wet for this purpose. The water acts as a preservative by washing off the spores of the fungi as fast as they are formed.

The various methods of preserving timber are: (1) By common salt, dissolved in water; (2) by impregnations of metallic substances, such as sulphates of copper, iron, etc.; (3) by chlorides of magnesium or zinc; (4) by creosoting; (5) by coal-tar; and (6) by carbolineum.

Timber may be treated with brine made from common salt, in the proportion of 1 pound of salt to 4 or 5 gallons of water, the timber being allowed to become thoroughly soaked with it: this method has the advantage of being cheap and easily applied. Sulphate of iron is also used, and has the recommendation of being economical and effective. Chlorides of magnesium and zinc are used for preserving mine-timber. In the zinc-process, a solution of chloride of zinc is forced into the timber under pressure. The solution consists of 1 part of liquid chloride of zinc at a specific gravity of 1·5, mixed with 35 gallons of water; 1 gallon of this solution weighs 15 lbs. and contains 3½ lbs. of pure metallic zinc. This process is said to make the wood firm, hard and proof against the attacks of insects and dry rot. The Aitken process was described in a paper by Mr. Robert Martin, and need not here be repeated.*

The impregnation of timber with crude creosote-oil, first used in 1842, is one of the best methods of preserving timber, but it has the disadvantage, especially for mine-timber, that it causes the wood to take fire readily, and is, therefore, not so suitable for underground work. For railway-sleepers and for use underground where there is no danger of fire, such as on wet roads, creosoting will add greatly to the life of the wood. The effects of creosote are threefold: (1) It fills the pores and avoids saturation with water; (2) it destroys organic life; and (3) the carbonic acid which it contains coagulates the albuminoid and prevents decay.

Painting of timber with liquid tar is sometimes resorted to, but it has the disadvantage of rendering the timber liable to ignition. Painting the timber with ordinary whitewash gives good results.

* *Trans. Inst. M.E.*, vol. x., page 531.

Carbolineum is used to a limited extent for preserving pit-props and is said to give good results, although it seems to be rather expensive for general colliery work: 1 gallon will cover 300 to 450 square feet of timber. It is applied by painting with a brush, or by steeping in a tank.

While preservatives undoubtedly prolong the life of timber in underground workings, they seem, at the same time, to decrease its strength to a considerable extent. Prof. Louis showed that timber thoroughly creosoted was diminished in strength to the extent of 8·5 per cent., while woods treated by the Aitken process were weakened from 8 to 20 per cent., according to the kind of timber treated. It would be interesting to have the opinion of members of the Institute, who use preservatives for timber, as to what is the apparent diminution of strength in timber so treated.

Table XI. shows the results of a number of tests made at Saint-Eloy, France, upon different methods of treating oak, fir, pine, beech, birch and poplar woods. Two specimens out of every ten experimented on were used in the natural state. The others were treated with solutions of (1) tar, (2) chloride of zinc, (3) sulphate of copper, (4) sulphate of iron, and (5) creosote.*

Table XI.—Showing the Relative Durations of each of the Different Woods, taking Un-preserved Wood as Unity.

Name of Preservative.	Name of Wood.					
	Oak.	Fir.	Pine.	Beech.	Birch.	Poplar.
Tar	28·7	263·5	87·5	105·4	26·2	150·5
Chloride of zinc ..	10·5	50·0	26·3	18·6	52·5	34·7
Sulphate of copper ...	42·1	12·0	8·0	1·8	2·5	15·5
Sulphate of iron ...	18·0	12·5	4·2	4·7	3·7	2·9
Creosote	1·7	2·5	4·4	0·6	3·3	1·3

The President (Mr. J. T. Forgie) was not in favour of the deputy system of propping as used in the North of England, and argued that where, as in Scotland, the miner was held responsible and was supposed to look after his own safety, there was more chance of his noticing any danger, and properly attending to his working-place; he was always on the spot, whereas a deputy might not be there when a prop was most

* "Effets de diverses Préparations sur la Durée de Bois," *Comptes-rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1890, page 225.

required. There were arguments for both sides, but he thought that the Scottish system of making the miner responsible was the most likely one to secure attention to the state of the roof and sides. He agreed with Mr. Kerr that good roofs required as much propping to maintain them as bad roofs, and he thought that many of the accidents from falls were due to want of timely propping of apparently good roofs. Another point was the effect of the introduction of the safety-lamp as against the naked light, in the matter of falls from sides and roof. With the safety-lamp, which was unwieldy and insufficient as compared with the other source of light, the miner could not see around him so well, and was not so well able to detect flaws in the roof. Accordingly, in his opinion, so long as miners were required to work with the present insufficient safety-lamps, the members need not look for much improvement as regards accidents from falls of roof and sides. There was no doubt that, at the pit-bottom or on a long haulage road, iron or steel girders could be used to great advantage. He thought that the expense of protecting a road with iron or steel girders was at least double that of timber—especially if the timber used was proportionate to the strength of the metal; and further, it was more expensive to erect iron supports. He had considerable experience of the preservation of timber, and found that creosoting was an enormous advantage. In a return airway, untreated larch was renewed about every 12 months; while creosoted Scotch fir at the end of 5 years was as good as when it was put in. At the same time he should mention that creosoted timber was reduced in strength, and became more brittle.

The discussion of the paper was adjourned.

THE INSTITUTION OF MINING ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN THE MASON UNIVERSITY COLLEGE, BIRMINGHAM, SEPTEMBER 13TH, 1898.

MR. GEORGE LEWIS, PAST-PRESIDENT, IN THE CHAIR.

DEATH OF MR. A. M. CHAMBERS.

The CHAIRMAN (Mr. George Lewis), in opening the proceedings, said that the members had heard with regret of the death of their late respected President, Mr. Arthur M. Chambers, who was a man of distinguished ability and had signalized himself in a variety of ways in connexion with the Institution and in the coal-trade. He proposed "that this Institution expresses its deep sympathy and condolence with the family of their late President, through whose death the Institution has suffered great loss."

The resolution was passed unanimously and in silence.

ELECTION OF OFFICERS.

The SECRETARY announced the election of the following officers by the Council:—

PRESIDENT.

Mr. J. A. LONGDEN.

VICE-PRESIDENTS.

Mr. WM. ARMSTRONG.	Mr. JAMES HAMILTON.	Mr. JOEL SETTLE.
Mr. W. H. CHAMBERS.	Mr. W. D. HOLFORD.	Mr. J. B. SIMPSON.
Mr. W. COCHRANE.	Sir WILLIAM T. LEWIS.	Mr. G. BLAKE WALKER.
Mr. J. T. FORGIE.	Mr. GEORGE MAY.	Mr. JAMES WALLACE.
Mr. G. B. FORSTER.	Mr. M. H. MILLS.	Mr. R. S. WILLIAMSON.

TREASURERS.

Messrs. LAMBTON & Co., The Bank, Newcastle-upon-Tyne.

AUDITORS.

Messrs. JOHN G. BENSON & SON, Newcastle-upon-Tyne.

STUDENT'S PRIZE ESSAY.

The SECRETARY reported that the Council had presented to Mr. G. C. Allsebrook the prize (offered to students) for his paper on "Coal-cutting by Machinery."*

The SECRETARY read the Annual Report of the Council as follows :—

THE NINTH ANNUAL REPORT OF THE COUNCIL.

In consequence of the continued success that has attended the formation, nine years ago, of the Institution, the Council during the past year unanimously agreed that the name should be altered to The Institution of Mining Engineers.

The six affiliated societies comprize :—The Chesterfield and Midland Counties Institution of Engineers; the Midland Institute of Mining, Civil and Mechanical Engineers; the Mining Institute of Scotland; the North of England Institute of Mining and Mechanical Engineers; the North Staffordshire Institute of Mining and Mechanical Engineers; and the South Staffordshire and East Worcestershire Institute of Mining Engineers.

The Council trust that success will attend their efforts, in order that the Institution may embrace the whole of the societies devoted to the advancement of mining, metallurgy and their allied industries; and they urge members who are connected with similar societies to use their influence in favour of federation. The position of the Institution would then become more effective, and the value of the *Transactions* would be materially enhanced.

The following table exhibits the progress of the membership of the Institution since its formation on July 1st, 1889 :—

Year.	No. of Members.	No. of Non-Federated.	Totals.
1889-90	1,189	50	1,239
1890-91	1,187	9	1,196
1891-92	1,415	19	1,434
1892-93	1,533	19	1,552
1893-94	2,068	123	2,191
1894-95	2,210	109	2,319
1895-96	2,301	81	2,382
1896-97	2,447	60	2,507
1897-98	2,462	47	2,509

Meetings of the Institution have been held in Scotland, Newcastle-upon-Tyne and London, and the Council are pleased to congratulate the

* *Trans. Inst. M.E.*, vol. xvi., page 67.

members upon the satisfactory attendance at these meetings, and to express their thanks to the gentlemen who kindly opened their works to the inspection of the members. A Students' Meeting was held in Newcastle-upon-Tyne in August, 1897.

The Council are endeavouring to make arrangements with various colonial mining societies, by which the members will be able to obtain their publications on favourable terms. The details will be announced to the members, as soon as the proposed arrangements are approved by the societies concerned.

The Council have awarded prizes to the writers of the following papers, which are printed in the *Transactions* (vols. xii. and xiii.) for the year 1896-97 :—

"Suggested Rules for the Recovery of Coal-mines after Explosions." By Mr. W. E. Garforth.

"The Cost and Efficiency of Safety-explosives as Compared with Gunpowder." By Mr. Henry Hall.

"The Phenomena of Colliery Explosions." By Mr. Donald M. D. Stuart.

"The Lake Superior Iron-ore Region, U.S.A." By Mr. Horace V. Winchell.

The Students' Prize has been awarded to Mr. Andrew Burt for his essay on "The Methods of Working Minerals, Secondary Haulage, and Ventilation in Fifeshire."

Presidential addresses have been delivered during the year to the members of The Institution of Mining Engineers, by the late Mr. A. M. Chambers ; the Mining Institute of Scotland, by Mr. J. T. Forgie; the North of England Institute of Mining and Mechanical Engineers, by Mr. George May ; and the North Staffordshire Institute of Mining and Mechanical Engineers, by Mr. Joel Settle.

The members may be congratulated upon the high standard of the papers which have been printed in the *Transactions*, and the Council trust that papers will be contributed as liberally as heretofore. In addition, members are invited to contribute to the discussion of papers, by sending their written remarks to the Secretary.

The papers on geology comprize :—

"Report of the Delegate to the International Geological Congress." By Mr. L. L. Belinfante.

"Mining in British Columbia." By Mr. W. M. Brewer.

"Notes on the Change in the Character of the Barnsley Coal-seam, between Rotherham and Pontefract." By Mr. H. St. John Durnford.

"Coal-fields of Chili." By Mr. Rowland Gascoyne.

"Notes on the Geology of Finland." By Principal H. P. Gurney.

"Observations on some Gold-bearing Veins of the Coolgardie, Yilgarn and Murchison Gold-fields, Western Australia." By Mr. Edward Halse.

"The Kalgoorlie Mines of the Great Western Australian Gold Backbone." By Mr. David H. Lawrance.

"Occurrences and Mining of Manjak in Barbados, West Indies." By Mr. Walter Merivale.

"The Siliceous Iron-ores of Northern Norway." By Mr. H. T. Newbigin.

"The Gold Regions of Alabama, U.S.A." By Mr. Wm. B. Phillips.

"Cheshire Salt-mines." By Mr. C. E. de Rance.

"Hydrothermal Gold-deposits at Peak Hill, Western Australia." By Mr. Frank Reed.

"The South Rand Coal-field, and its Connexion with the Witwatersrand Banket Formation." By Mr. A. R. Sawyer.

"The Geology of the Congo." By Mr. X. Stainier.

"Supplementary Notes to Mr. R. Gascoyne's paper on the 'Coal-fields of Chili.'" By Mr. G. Blake Walker.

"The Gold-fields of the Hauraki District, New Zealand." By Mr. John Andrew Wauchope.

Mining engineering has been dealt with in the following papers :—

"The Re-opening of Wallsend Colliery." By Mr. Henry Ayton.

"Irish Channel Tunnel." By Mr. James Barton.

"The Mining Industry of Belgium."' By Mr. A. Briart.

"The Methods of Working Minerals, Secondary Haulage and Ventilation in Fifeshire." By Mr. Andrew Burt.

"Submarine Coal-mining at Bridgeness, N.B." By Mr. Henry M. Cadell.

"Notes on Rearer Workings." By Mr. John Cadman.

"Davis Calyx-drill." By Mr. Francis Harley Davis.

"Secondary Haulage: Cost of Putting and Driving." By Mr. T. E. Forster and Mr. F. R. Simpson.

"Coal-cutting by Machinery." By Mr. W. T. Goolden.

"Technical Education in Mining." By Prof. Henry Louis.

"The Strength of Pit-props." By Prof. Henry Louis.

"Occurrences and Mining of Manjak in Barbados, West Indies." By Mr. Walter Merivale.

"A Method of Dealing with Running-sand when met with in Borings." By Mr. Geo. B. Reynolds.

The following papers have been contributed on mechanical engineering :—

"Gas Power." By Mr. J. Emerson Dowson.

"The Freakley Steam-carriage." By Mr. W. Freakley.

"The Brown Hydraulic System for Underground Pumping and Haulage." By Mr. Wm. F. Lang.

"Internal Corrosion of Wire Ropes." By Mr. Thos. G. Lees.

"The Strength of Pit-props." By Prof. H. Louis.

"Roller-bearings." By Mr. W. Bayley Marshall.

"Underground Steam-appliances, and Temperature of the Strata at Niddrie Collieries." By Mr. Robert Martin.

"A One-rail or Trestle System of Light Railway." By Mr. Fred. J. Rowan.

"Notes on a Water-heater recently erected at Cadzow Colliery." By Mr. William S. Thomson.

Mine-ventilation, safety-appliances, etc., have been discussed in the following papers :—

"Experiments with the Shaw Gas-tester." By Prof. P. Phillips Bedson and Mr. J. Cooper.

"The Walcher Pneumatophore, and the Employment of Oxygen for Life-saving Purposes." By Mr. Richard Cremer.

"Wagner Portable Pneumatic Safety-stopping for Mining Purposes." By Mr. Richard Cremer.

"Comparative Experiments on Models of a Capell, a Schiele and a Crighton Excelsior Fan, under the same Conditions." By Mr. John Crighton.

"Suggested Rules for the Recovery of Coal-mines after Explosions." By Mr. W. E. Garforth.

Matters of legislation have been treated upon in the following papers :—

"Irish Legislation on Mining and Coal up to the Year 1800." By Mr. H. G. Graves.

"The Workmen's Compensation Act, 1897." By Mr. Edward B. Wain.

Electricity and its applications have been discussed in the following papers :—

"Latest Developments and the Practical Application of Alternating Multiphase Machinery for Electric-power Transmission." By Mr. Walter Dixon.

"Electric Blasting." By Mr. Wm. Maurice.

Explosives and blasting have been the subjects of the following papers :—

"Memorandum on the Proposed Station for Testing Explosives at Woolwich." By the Joint Committee of the Chesterfield and Midland Counties Institution of Engineers and the Midland Institute of Mining, Civil and Mechanical Engineers.

"Report on an Explosives Testing-station." By the Joint Committee of the Chesterfield and Midland Counties Institution of Engineers and the Midland Institute of Mining, Civil and Mechanical Engineers.

"Kynite, a new Safety-explosive." By Mr. W. Cullen.

"Photographs of Flashes of Electric Detonators." By Mr. L. W. de Grave.

"High-grade Gunpowder." By Mr. A. F. Hargreaves.

"Electric Blasting." By Mr. Wm. Maurice.

"The Walker Hollow Needle for Firing High Explosives." By Mr. J. Mein.

"Some Defects in Gunpowder as a Blasting Agent." By Mr. W. J. Orsman.

"New Hydraulic Mining Cartridge." By Mr. James Tonge.

Appliances used for the shipment of coal have been described in the following papers :—

"Telescopic Spout for saving Breakage of Coal in the First Shipment." By Mr. E. W. Crone.
"Coal-shipping Plant at Wallsend Colliery." By Mr. J. M. Moncrieff.
"Coal-shipping by Belts." By Mr. John Morison.
"Shipment of Coal." By Mr. H. Richardson."

Metallurgy has been discussed in the following papers :—

"Pyritic Smelting." By Mr. Wm. Lawrence Austin.
"Notes on the Iron Industry of the Urals." By Prof. Henry Louis.
"Historical and Archæological Memoir on the Ironworks of the South-east of England (particularly of Sussex)." By Mr. Mark Antony Lower.
"The Direct Treatment of Auriferous Mispickel-ore by the Bromo-cyanide Process at Deloro, Ontario, Canada." By Mr. Hugh K. Picard.

The miscellaneous papers have included :—

"Mining Mortality." By Mr. James Barrowman.
"Slavery in the Coal-mines of Scotland." By Mr. James Barrowman.
"Memoir of the late Thomas John Bewick." By Mr. T. Burrell Bewick.
"Barometer, Thermometer, etc., Readings for the Year 1897." By Mr. M. Walton Brown.
"The Equipment of Exploring Expeditions." By Mr. M. Walton Brown.
"Historical Notes on Wallsend Colliery." By Mr. T. E. Forster.
"The Manufacture of Fire-clay Goods from the Under-clays of Thin Coal-seams." By Mr. Philip Kirkup.
"The Otto Coke-oven." By Dr. C. Kroseberg.
"Explosions in Air-compressors and Receivers." By Mr. T. G. Lees.

The preceding list, including 74 papers, demonstrates the varied nature of the memoirs printed in the *Transactions* (vols. xiv. and xv.) during the past year.

The "Notes of Papers (191) on the Working of Mines, Metallurgy, etc., from the Transactions of Colonial and Foreign Societies and Colonial Publications" have been continued, and should prove of value to the members.

The Council have to express their deep regret at the unexpected death, on August 29th, 1898, of the President, Mr. A. M. Chambers, very shortly prior to the close of his year of office.

BOOKS, ETC., ADDED TO THE LIBRARY.

African Review, Nos. 259-298.
Annales des Mines de Belgique, vol. ii., No. 4; vol. iii., Nos. 1-3.
Australasian Institute of Mining Engineers, Transactions, vols. i.-iv.
Australian Mining Standard, Nos. 464-502.
British Association for the Advancement of Science, Report of the Sixty-Seventh Meeting held at Toronto in August, 1897, octavo, 907 pages.

British Society of Mining Students, Journal, vol. xx., parts 3-6.

Chambers, T., A Land of Promise: An Account of the Conditions and Resources of Western Australia, demy octavo, 60 pages.

Chemical and Metallurgical Society of South Africa, Proceedings, vol. i., May, 1894 to January, 1897; Journal, vol. i., Nos. 1-5.

Coal and Iron, Nos. 131-181.

Cory Brothers, British Coal Trade and Freight Circular, October 31st, 1897, to July 31st, 1898.

Derby Free Library, Twenty-Sixth Annual Report of the Committee, royal octavo, 35 pages.

Electrical Installation Rules, Liverpool, London, and Globe Insurance Company, 1898, 34 pages.

Engineering and Mining Journal, vol. lxiv., Nos. 18-26; vol. lxv., Nos. 1-26; vol. lxvi., Nos. 1-4.

Federated Canadian Mining Institute, Journal, vol. ii., 1897.

Franklin Institute of the State of Pennsylvania, U.S.A., Journal, vol. cxliv., Nos. 5-6; vol. cxlv., Nos. 1-6; vol. cxlvi., No. 1.

Geological Survey of New South Wales, Records, vol. v., Nos. 2-4.

—, Mineral Resources, 1898, Nos. 1-2.

Hatch, F. H., A Geological Survey of the Witwatersrand and other Districts in the Southern Transvaal, demy octavo, 17 pages.

MacDevitt, E. O., Handbook of Western Australia: being a Short Account of its History, Resources, Scope for Settlement, and Land Laws, crown octavo, 31 pages.

McMillan, A. J., The Mineral Resources of British Columbia and the Yukon, A Lecture delivered at the Imperial Institute, London, on December 6th, 1897, crown octavo, 20 pages.

Manchester Geological Society, Transactions, vol. xxv., Nos. 12-16.

Massachusetts Institute of Technology, Technology Quarterly, vol. x., part 4; vol. xi., part 1.

Mines, 1897, List of the Plans of Abandoned Mines deposited at the Home Office, corrected to December 31st, 1897, foolscap folio, 63 pages.

Mines and Quarries, 1897, Report of C. Le Neve Foster, Esq., H.M. Inspector of Mines for the North Wales District (No. 9), foolscap folio, 63 pages.

New Zealand Mines Department, Wellington, Report for the year 1897.

Ogilvie, W., Lecture on the Klondike Mining District, delivered at Victoria, British Columbia, November 5th, 1897, imperial octavo, 14 pages.

South Wales Institute of Engineers, Transactions, vol. xx., Nos. 6-8.

Western Australia, Department of Mines, Report for the year 1896, with Supplementary Notes on part of 1897, foolscap folio, 75 pages.

—, Land Selector's Guide to the Crown Lands of Western Australia, being Explanatory Notes respecting Land Selection, etc., demy octavo, 31 pages.

—, Legislative Assembly, Financial Statement of the Right Honourable Sir John Forrest, made on the 16th November, 1897.

Yorkshire College, Leeds, Twenty-third Annual Report, Victoria University, 1896-97, demy octavo, 106 pages.

EXCHANGES.

Annales des Mines de Belgique.
Australasian Institute of Mining Engineers.
British Association for the Advancement of Science.
British Society of Mining Students.
Chemical and Metallurgical Society of South Africa.
Federated Canadian Mining Institute.
Franklin Institute of the State of Pennsylvania, U.S.A.
*General Mining Association of the Province of Quebec, Canada.
*Institution of Mining and Metallurgy.
*Lake Superior Mining Institute.
Manchester Geological Society.
Massachusetts Institute of Technology.
*Mining Society of Nova Scotia, Canada.
New South Wales, Department of Mines and Agriculture, Geological Survey.
*New Zealand Institute of Mining Engineers.
*Ontario Mining Institute.
*Revue Universelle des Mines, de la Métallurgie, etc.
*South African Republic, Department of the State Mining Engineer.
South Wales Institute of Engineers.

* No publications received during current year.

July 31st, 1898.

THE LOCAL INSTITUTES IN ACCOUNT WITH THE INSTITUTION OF MINING ENGINEERS, FOR THE YEAR ENDING JULY 31ST, 1898.

Dr.	No. of Members. Federated.	No. of Members. Non-Federated.	Balance due at the beginning of the year.	Amounts falling due during the year. Calls made during the year.	Excerpts.	Transactions, Reducing Plates, etc.	Totals.
			£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Chesterfield and Midland Counties Institution of Engineers ...	322	...	14 18 0	305 18 0	12 12 7	12 16 8	346 5 3
Midland Institute of Mining, Civil and Mechanical Engineers	274	...	9 13 0	260 6 0	9 3 0	10 16 8	289 18 8
Mining Institute of Scotland	422	47	10 15 6	424 8 0	21 5 0	6 6 8	462 15 2
North of England Institute of Mining and Mechanical Engineers	1,142	...	43 1 9	1,084 18 0	36 14 5	32 12 8	1,197 6 10
North Staffordshire Institute of Mining and Mechanical Engineers	161	...	16 19 3	152 19 0	2 15 2	3 16 8	176 10 1
South Staffordshire and East Worcestershire Institute of Mining Engineers...	128	...	61 13 1	121 12 0	1 19 8	6 16 8	192 1 5
Totals	2,449	47	157 0 7	2,350 1 0	84 9 10	73 6 0	2,664 17 5

Cr.	Amounts paid during the year. Balance from previous year.	Calls.	Excerpts.	Transactions, Reducing Plates, etc.	Totals.	Balance due at July 31st, 1898.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Chesterfield and Midland Counties Institution of Engineers ...	14 18 0	283 2 0	12 12 7	5 10 0	316 2 7	30 2 8
Midland Institute of Mining, Civil and Mechanical Engineers	9 13 0	252 14 0	9 3 0	8 3 4	279 13 4	10 5 4
Mining Institute of Scotland	10 15 6	422 19 0	18 13 6	2 0 0	454 8 0	8 7 2
North of England Institute of Mining and Mechanical Engineers	43 1 9	983 5 0	18 8 8	6 0 0	1,050 15 5	146 11 5
North Staffordshire Institute of Mining and Mechanical Engineers	16 19 3	146 6 0	2 9 2	0 10 0	166 4 5	10 5 8
South Staffordshire and East Worcestershire Institute of Mining Engineers	61 13 1	96 18 0	0 9 2	...	159 0 3	33 1 2
Totals	157 0 7	2,185 4 0	61 16 1	22 3 4	2,426 4 0	238 13 5

Dr. THE TREASURER IN ACCOUNT WITH
FOR THE YEAR

		£ s. d.	£ s. d.	£ s. d.
July 31, 1897.				
To Balance at Bank			634 8 0	
" " in Treasurer's hands			60 15 7	
				695 3 7
To Subscriptions for year ending July 31, 1897—				
Federated—				
Chesterfield and Midland Counties Institution of Engineers		£11 18 0		
Midland Institute of Mining, Civil and Mechanical Engineers		7 13 0		
Mining Institute of Scotland		0 17 0		
North of England Institute of Mining and Mechanical Engineers		1 14 0		
North Staffordshire Institute of Mining and Mechanical Engineers		10 4 0		
South Staffordshire and East Worcestershire Institute of Mining Engineers ...		47 12 0		
			79 18 0	
Non-Federated—				
Mining Institute of Scotland			6 0 0	
				85 18 0
To Subscriptions for year ending July 31, 1898—				
Federated—				
Chesterfield and Midland Counties Institution of Engineers		£283 2 0		
Midland Institute of Mining, Civil and Mechanical Engineers		252 14 0		
Mining Institute of Scotland		399 19 0		
North of England Institute of Mining and Mechanical Engineers		983 5 0		
North Staffordshire Institute of Mining and Mechanical Engineers		146 6 0		
South Staffordshire and East Worcestershire Institute of Mining Engineers ...		96 18 0		
			2,162 4 0	
Non-Federated—				
Mining Institute of Scotland			23 0 0	
				2,185 4 0
Carried forward				£2,966 5 7

THE INSTITUTION OF MINING ENGINEERS. **Cr.**
ENDING JULY 31, 1898.

July 31, 1898.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
By Printing—												
Transactions, Vol. XII., printing	48	6	2									
" " XII., plates...	76	2	9									
				124	8	11						
" " XIII., printing	570	16	2									
" " XIII., plates...	192	1	1									
				762	17	3						
" " XIV., printing	534	19	8									
" " XIV., plates...	212	3	0									
				747	2	8						
" " XV., printing	200	0	0									
" " XV., plates...	3	13	0									
				203	13	0						
" " XVI., plates...	0	16	6	0	16	6						
							1,838	18	4			
Excerpts, Vol. XII....				0	12	6						
" " XIII....				77	0	0						
" " XIV....				93	3	0						
							170	15	6			
Circulars				......			26	13	3			
Proofs of Papers for General Meetings				......			17	9	0			
										2,053	16	1
By Addressing Transactions				......			30	14	3			
" Postages—Circulars				24	17	4						
" " Correspondence				23	19	10						
" " Transactions				320	15	6						
							369	12	8			
" Stationery, etc.				......			43	14	11			
" Insurance of Transactions				......			2	0	0			
" Binding—Library				2	18	8						
" " Sundries				1	8	0						
" " Transactions				34	6	9						
							38	13	5			
" Reporting General Meetings				......			12	4	6			
" Expenses of General Meetings				......			16	7	1			
" Incidental Expenses				......			2	19	3			
" Petty Cash				......			10	4	0			
" Salaries, Wages, Auditing, etc.				......			498	1	6			
" Indexing Transactions				......			33	3	8			
Carried forward							£1,057	15	3	2,053	16	1

Dr. THE TREASURER IN ACCOUNT WITH

	£ s. d.	£ s. d.	£ s. d.
Brought forward			2,966 5 7
To Local Publications and Authors' Copies—	1896-97.	1897-98.	
The Institution of Mining Engineers	1 12 11	22 15 9	
Chesterfield and Midland Counties Institution of Engineers	......	12 12 7	
Midland Institute of Mining, Civil and Mechanical Engineers	......	9 3 0	
Mining Institute of Scotland	2 18 6	18 13 6	
North of England Institute of Mining and Mechanical Engineers	......	18 8 8	
North Staffordshire Institute of Mining and Mechanical Engineers	1 15 3	2 9 2	
South Staffordshire and East Worcestershire Institute of Mining Engineers	1 11 1	0 9 2	
	7 17 9	84 11 10	
			92 9 7
To Sales of Transactions, etc.—			
Chesterfield and Midland Counties Institution of Engineers	1896-97. 8 0 0	1897-98.	
Midland Institute of Mining, Civil and Mechanical Engineers	2 0 0	6 13 4	
Mining Institute of Scotland	......	2 0 0	
North of England Institute of Mining and Mechanical Engineers	41 7 9	......	
North Staffordshire Institute of Mining and Mechanical Engineers	4 0 0	......	
South Staffordshire and East Worcestershire Institute of Mining Engineers	11 0 0	......	
Members, etc.	......	199 19 5	
	61 7 9	208 12 9	
			270 0 6
To Reducing Plates—			
Chesterfield and Midland Counties Institution of Engineers	1896-97.	1897-98. 5 10 0	
Midland Institute of Mining, Civil and Mechanical Engineers	......	1 10 0	
Mining Institute of Scotland	1 0 0	......	
North of England Institute of Mining and Mechanical Engineers	......	6 0 0	
North Staffordshire Institute of Mining and Mechanical Engineers	1 0 0	0 10 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	1 10 0	......	
Members, etc.	......	7 16 6	
	3 10 0	21 6 6	
			24 16 6
To Advertizements			726 12 4
			£4,080 4 6

THE INSTITUTION OF MINING ENGINEERS.—*Continued.* Cr.

	£ s. d.	£ s. d.	£ s. d.
Brought forward		1,057 15 3	2,053 16 1
By Travelling Expenses—Secretary ...	12 15 2		
„ „ „ Treasurer ...	8 5 0		
„ „ „ Sundries... ...	3 5 0		
		24 5 2	
			1,082 0 5
By Advertizements—Commission	135 1 4		
„ „ Printing	2 18 2		
		137 19 6	
„ Prizes, Vols. X. and XI.	20 0 0		
„ „ „ XII. and XIII.	20 0 0		
„ „ Students' Essay, Vol. XIII. ...	5 0 0		
		45 0 0	
„ Abstracts of Foreign Papers, Vols. XIII. and XIV.	......	78 15 0	
„ Barometer Readings, etc....	......	6 18 6	
„ Calendar	.....	14 3 6	
„ Mechanical Ventilators Committee ...	......	167 10 2	
„ Library—Books	......	0 5 6	
„ Typewriter	......	21 7 0	
			471 19 2
			3,607 15 8
„ Balance at Bank	......	449 5 7	
„ „ in Treasurer's hands	......	23 3 3	
			472 8 10
			£4,080 4 6

I have examined the above account of receipts and payments, with the books and vouchers relating thereto, and certify that in my opinion it is correct.

JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
September 10*th*, 1898.

Liabilities.

	£	s.	d.	£	s.	d.
Sundry Creditors—						
Advertizements Paid in Advance	44	10	0			
Printing, etc.	577	0	0			
Postage of Transactions	120	0	0			
Abstracts of Foreign Papers	50	0	0			
Barometer Readings	8	0	0			
Prizes for Papers, Vols. XIV. and XV....	25	0	0			
Index, Vol. XV.	10	0	0			
Advertizement Commission	76	3	10			
				910	13	10
Balance of Assets over Liabilities				989	4	3
				£1,899	18	1

I have examined the above Balance Sheet, with the books and vouchers relating thereto, and certify that in my opinion it exhibits a correct view of the affairs of the Institution.

I have accepted the asset "Transactions in Stock" as valued by the Officials of the Institution.

JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
December 29th, 1898.

ENGINEERS.—BALANCE SHEET, JULY 31, 1898.

Assets.

	£ s. d.	£ s. d.
Balance at Bank	449 5 7	
„ in Treasurer's hands	23 3 3	
		472 8 10
Subscriptions Unpaid, Year ending July 31, 1898—		
Federated—		
Chesterfield and Midland Counties Institution of Engineers	22 16 0	
Midland Institute of Mining, Civil and Mechanical Engineers	7 12 0	
Mining Institute of Scotland	0 19 0	
North of England Institute of Mining and Mechanical Engineers	101 13 0	
North Staffordshire Institute of Mining and Mechanical Engineers	6 13 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	24 14 0	
		164 7 0
Non-Federated—		
Mining Institute of Scotland	0 10 0	
		0 10 0
Local Publications and Authors' Copies Unpaid—		
Mining Institute of Scotland	2 11 6	
North of England Institute of Mining and Mechanical Engineers	18 5 9	
North Staffordshire Institute of Mining and Mechanical Engineers	0 6 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	1 10 6	
		22 13 9
Transactions Sold—		
Chesterfield and Midland Counties Institution of Engineers	7 6 8	
Midland Institute of Mining, Civil and Mechanical Engineers	2 13 4	
Mining Institute of Scotland	3 6 8	
North of England Institute of Mining and Mechanical Engineers	26 12 8	
North Staffordshire Institute of Mining and Mechanical Engineers	3 6 8	
South Staffordshire and East Worcestershire Institute of Mining Engineers	6 6 8	
		49 12 8
Reducing Plates—		
Mining Institute of Scotland	1 0 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	0 10 0	
		1 10 0
Advertizements unpaid		314 3 6
		1,025 5 9
Transactions in Stock		874 12 4
		£1,899 18 1

DISCUSSION OF PROF. H. LOUIS' PAPER ON "THE STRENGTH OF PIT-PROPS."*

Mr. H. R. HEWITT (H.M. Inspector of Mines. Derby) agreed with Prof. Louis in condemning methods used by importers in marking timber as being likely to weaken the props. He would like to have Prof. Louis' opinion of the value of such seasoning-sheds for timber as were used on the Continent, and also on the advantages of chamfering props.

Prof. H. LOUIS (Newcastle-upon-Tyne) did not think that seasoning-sheds were so necessary in Great Britain as in other countries, owing to the different climatic conditions. He had purposely omitted the consideration of this subject, as it led to highly mathematical problems on the one hand and highly practical ones on the other. He did not think that the proportionate length of the prop to the timber had any effect on the strength of the prop, but it was stated in treatises on mechanics that when the length of a vertical prop exceeded the proportionate length of timber in the ratio of 30 to 1, the length might be disregarded, but when it exceeded 35 to 1 the length became a factor. In pit-props, however, the length never exceeded 30 times the diameter. The strength of the prop was only the strength of the weakest point, and in that respect the short prop had an advantage. It had been determined by mathematicians that a prop with a half round end was stronger than one with the end sawn off square; and in the latter case the water was liable to gather in the hollow and rot the prop.

Mr. F. COULTHARD (Whitehaven) wrote that Mr. C. E. de Rance stated that larch-timber from the Lake district "was of no use at all for mining purposes."† Surely he must have made a mistake, as mining engineers in the West Cumberland district considered that larch-timber was the toughest and best timber that they could get, and paid a higher price for it than any other. He might say that, after 23 years' experience, he had never found any other timber to equal it in strength for use in coal or iron-ore mines, and it was actually exported to Spain, for use in mines in that country, as being the most suitable timber for withstanding heavy pressure. It could not be possible, that the failure was due to its quick maturing, as he was informed (and he believed correctly) that in the

* *Trans. Inst. M.E.*, vol. xv., page 343. † *Ibid*, page 361.

Lake district no larch-timber was cut under 40 years of age, and that the majority was over 50 years old, and, consequently, could not possibly be called young larch. Possibly Mr. C. E. de Rance had the striplings or wood cut out for thinning purposes palmed upon him, otherwise he (the writer) could not imagine how he could condemn larch grown in the Lake district.

DISCUSSION OF MR. F. H. DAVIS' PAPER ON "THE DAVIS-CALYX DRILL."*

Mr. N. R. Griffith (Ruabon) said that he had seen a drill at work and it was remarkably effective. The Kent Coal Exploration Company had three machines in use, and they were boring efficiently. He did not know the speed of the drill.

Mr. A. H. Stokes (Derby) remarked that stratigraphieal accuracy was the principal thing in boring. He would like to know whether Mr. Griffith had had experience with this drill in boring through a seam of coal.

Mr. N. R. Griffith replied that he had had no experience as yet, but he hoped to have.

Mr. A. H. Stokes said that in boring through a soft coal-seam it would break up and the pieces grind together, but if the coal was hard there was no difficulty, if care were exercised.

Mr. M. H. Mills (Mansfield) said that he had known of a borehole passing through a seam of coal at a depth of 2,000 feet, and the tool brought up a block about the size of his fist. The principal feature of this method was the economy, as it was much cheaper than any other system.

Prof. H. Louis said that he had been exceedingly interested in the work of the Davis-calyx drill. He had seen a very ingenious form of the diamond drill in which the weight of the rods was relieved by hydraulic pressure, and he had seen several cores of coal drawn out.

Mr. Frank Baker (London) wrote that he had read the discussion on the above paper with interest. He had been closely connected with the above drill from its inception, and had seen a test-boring made for

* *Trans. Inst. M.E.*, vol. xv., page 363.

the government of Victoria, Australia, to a depth of 700 feet through faulty ground by hand-power—cutting 4¾ inches cores, and costing less than 4s. per foot. Since then, a boring had been made with this drill through several seams of coal at the Outtrim coal-mine, Victoria, and it had produced about 60 per cent. of the cores in a cylindrical form, the balance of 40 per cent. being accurately preserved in the chip-cup. He was present at Braakpan, near Johannesburg, in July, 1896, and saw the Davis calyx-drill cut through a 35 feet seam of coal in 9 hours, by Zulu hand-power—about 20 feet of this seam was brought to the surface in solid cores, and the balance was caught in the chip-cup, none of the coal being lost. Since that date, many other seams of coal had been cut with marked accuracy. Owing to the slow cutting movement of the cutter and core-barrel (from 3 to 15 revolutions per minute), there was very little friction or vibration, and the action was not at all likely to injure or jar the core into pieces, as was the case with the diamond drill, when grinding the coal at a speed sometimes exceeding 100 revolutions per minute. In conclusion, he might add that it was absolutely impossible for the calyx-drill to bore a crooked hole, for reasons which were obvious to anyone who would study the action and construction of this drill.

DISCUSSION OF MR. W. T. GOOLDEN'S PAPER ON "COAL-CUTTING BY MACHINERY."*

Mr. Roslyn Holliday (Pontefract) said it might interest the members to know that about 2 months ago they had started at Acton Hall colliery a Garforth polyphase coal-cutter, and found that it worked extremely well.

Mr. A. H. Stokes (H.M. Inspector of Mines, Derby) understood that the polyphase motor was like a jibbing horse, but he was glad to hear that someone had another opinion.

Mr. Roslyn Holliday (Pontefract) said he had seen one machine that worked in that way, but they had found no trouble with their machine. They had put on the motors themselves. They used a 500 volts current at the surface, and transformed it to 335 volts in the mine.

Mr. A. H. Stokes said that one of the chief objections to the use of coal-cutting machines was the noise that they made when in use. It

* *Trans. Inst. M.E.*, vol. xv., page 378.

prevented the miners from hearing any indication of the roof being likely to give way. In several collieries, it was now the practice to stop the machines every 10 minutes in order that the condition of the roof might be ascertained. Some of the machines were now being tried with helical teethed wheels, so that the noise was diminished as much as possible. He knew of a case in which a workman was killed, owing to the vibration of the machinery bringing down the roof.

Mr. W. SPENCER (Leicester) said that during an experience of several years he had never had an accident when using a coal-cutting machine, but he admitted that the noise was objectionable, and should be minimized as much as possible.

Mr. R. S. WILLIAMSON (Hednesford) said that he had had some experience of coal-cutting machines, and the most successful machines were disc-machines worked by electricity. Their practice was to stop the machine at intervals of 10 or 12 feet, and then examine the roof. The only disadvantage was that the workmen were not able to sprag within 6 feet of the spot where the disc-machine was at work. Three men were employed at each machine, although he believed that in most cases 2 would be sufficient. The machine took a 260 volts current, it had been running about 2 years, and only required slight repairs. The machine was used daily, and cut at a speed of 200 feet long by 5¼ feet under per 8 hours' shift, whereas the ordinary miner could only cut 11 feet by 4 feet in the same time.

Mr. EDMUND HOWL read the following paper on "The South Staffordshire Mines-drainage Scheme, with Special Regard to Electric-power Pumping":—

THE SOUTH STAFFORDSHIRE MINES-DRAINAGE SCHEME, WITH SPECIAL REGARD TO ELECTRIC-POWER PUMPING.

By E. B. MARTEN and EDMUND HOWL.

A few facts must be mentioned as to the work of the South Staffordshire Mines-drainage Commissioners in order to understand fully the special reasons for proposing the help of electric-power pumping which is the immediate subject of this paper.

Anyone who was familiar with the Black Country, as the South Staffordshire coal-field is frequently called, some 30 or 40 years ago must have wondered at the number of large pumping-engines required to keep the mines free from water, and could not fail to notice the manner in which the taking out of the remarkably thick coal-seams for which this district was famous had broken the surface of the ground, and so sunk the beds and banks of the rivers and watercourses in all directions as to create large sheets of water in numerous places, where water ought not to be, so that it was evident to the mere casual observer or passing stranger that it must be the great quantity of surface-water going down into the mines that made so many pumping-engines necessary.

Pumping the water at one mine to let it down into another near it was so obviously unscientific that much effort was made to find a remedy.

Following the wellknown dictum that "science is measurement," the real first step to a cure was the ascertaining of the exact extent of the mischief, and this was done under the auspices of the British Association for the Advancement of Science, who visited Birmingham in 1865. In their name, sufficiently full statistics were gathered to show that about 50,000,000 gallons of water were raised from the mines daily.* Calculation soon proved that such a quantity of water was far more than the rainfall could supply (bearing in mind the large quantity carried off the district by the rivers) and that the pumps were lifting the same water over and over again. A full investigation of the surface showed that the water ran back to the mines through the broken ground from what are called "swags," or surfaces depressed by mining below the proper natural outfall.

* The particulars were afterwards published in the *Transactions of the Dudley and Midland Geological and Scientific Society*, vol. ii., pages 128 to 135.

The state of the public rivers and streams was found to be deplorable, and the canals and canal-basins were also so much pulled about by mining operations as to overflow, and so contributed much water to the mines. The level of the water in canals and basins had to be maintained to work the traffic, and at least on one side the embankment had to be raised, but on the other or off-side the water spread into wide areas or lakes over ground full of cracks or insecure pits. In fact, in times of flood from heavy rain, large areas were so covered with water that the streams and canals could not be distinguished. Such a state of things was frequently seen from the London and North-Western railway when travelling between Dudley Port and Albion.

It was soon perceived that so extensive an evil could not be controlled satisfactorily by private enterprise under the ordinary powers of individuals. Consequently Parliamentary powers were sought in 1872, and such was the general fear of the loss of such quantities of coal as were threatened with hopeless inundation that the necessary powers were readily granted, the first South Staffordshire Mines-drainage Act being passed in 1873.

Help came from many quarters, and some rather unexpectedly. The canal companies, although much affected by the powers sought, gave general support, under the conviction that if some responsible body would mend and maintain the public rivers and streams, the owners of the canals and basins could make and keep them water-tight, and the frequent and expensive litigations as to flooding of mines would cease. Nearly every one approved of the repair of the surface, and it was wisely arranged that it should be dealt with apart from the pumping of water from the mines, which seemed to many a more formidable undertaking.

The Act of Parliament granted a universal and compulsory rate for surface-works on all mines gotten, but a separate form of rating for mines-drainage.

This paper deals more especially with the surface (75 square miles), and more particularly those 32 square miles of it called the Tipton district, where electric power is proposed to be used.*

A few facts, however, must be mentioned as to the pumping from the mines in this Tipton district. There were raised from the 32 square

* See Mr. H. Lea's "Presidential Address," *Trans. Inst. M.E.*, vol. i., page 163; and Mr. W. F. Clarke's "Presidential Address," *Trans. Inst. M.E.*, vol. iii., page 465, and Plate XXIX.

miles 36,000,000 gallons of water per day by 120 engines. Very little progress was made while the old pumping-engines over which the Commissioners had only limited control were worked, but when they put down the first-class engines of modern type, and acquired a few of the best of the old ones, by direct control more economic working was possible.

Since 1873, the surface-works had so decreased the mass of water to be dealt with that the daily quantity has been reduced to 9,000,000 gallons, or only one quarter of what it was at the commencement. This 9,000,000 gallons is supposed to be all that will have to be dealt with, but it does not come to the pumps, from the various underground pounds through the old workings in the ordinary ground, sufficiently freely to drain them to the level of the coal to be worked. Although all the water comes through higher measures and over barriers to the pumps, it leaves large areas pounded up, and so prevents the coal from being gotten.

To meet the necessities of the present state of things, it is desired to further improve the surface-works in extent and efficiency so as to reduce the "come" from the mines to only 6,000,000 gallons per day instead of 9,000,000 gallons, and to pump from some of the drowned pounds just referred to by means of a few smaller and semi-portable engines, leaving the bulk of the water to be dealt with by the larger engines already set up by the Commissioners, and of ample power to do the work.

It is not expected that the increased number of pumping-plants will have to be maintained permanently, because, as the collieries begin to be worked, after being freed from water, underground connexions will be made. Thus the original plan for concentrating the water will become effected in a natural way, and the water will be brought to the present pumping-engines, which are fixed in exactly the right places for collecting and dealing with it, and are fully equal to the work.

The surface-works include the purchase and removal of many water-mills, thus reducing the level of the main streams; also deepening, straightening, embanking and clearing all the streams so as to have a uniform gradient, and sufficient sectional area and a water-tight channel to convey water from the higher grounds, where the streams take their rise, right through the broken ground where mining has most affected them, to the outfall at the boundaries of the district. All the main streams are kept clear of mud and road silt, and frequently have to be cleared of sewage also before a free flow of water can be secured. Nearly all the smaller branches have also been cleared right up to their rise in the higher ground of the central part of the district.

Large areas sunk by mining operations below all natural outlets have been dealt with by surface pumping-engines raising the water to the nearest sound channel. Some of them are permanent, and others are stations visited periodically by portable pumping-engines.

It is difficult for a casual observer to realize the great improvement made by the surface-works, as the streams now look so natural in their present position that the former deplorable state of dilapidation cannot be remembered, but the result proves their efficiency, as it has reduced the "come" in the mines from 36,000,000 to 9,000,000 gallons per day. This result has been helped by the repairs of the canals and the systematic testing of canal-basins and cutting off of those found leaky or disused.

In 1895, a combined scheme for draining the mines and the surface was brought out. It proposed the establishment of two main pumping and hydraulic-power producing plants, underground levels, and a hydraulic-power distribution main, which power was not only to be used for working semi-portable deep pumps, but also to be made available for the actuating of surface-pumps situated in the low-lying areas.

A large proportion of that part of the scheme which referred to the driving of underground levels has been carried out. Three thousand feet of underground levels, consisting of a brick culvert 4½ feet in diameter (an extension of 1,850 feet of similar levels from the Bradley pumping-engine) has been driven in the lowest measure of the coal-seam known as the "bottom coal-holers" to the site of an old pumping-plant situated at Moxley, in the heart of the Bilston district, where the main pound gave a head of water of about 102 feet, or 45 pounds to the square inch. It was expected that, when this point was reached and the water commenced to be drawn off, the water in the adjoining mines would follow as the pressure in front was reduced, and by this means a large area of coal would be at once relieved. It was found, however, when this work was carried out, that only a few million gallons by this means were released from the main pound, and that the water stood up in the adjoining pits at practically the same height as it did before the level was driven and the water from the Moxley shaft run off. This state of things clearly shows that the old workings have become consolidated during the time the collieries have been under water since 1877, and that the lower measures are now so close that the water does not even pass by percolation under the heavy pressure of 45 pounds to the square inch.

The Commissioners were thus faced with the difficulty of either

having to make an underground level from the pumps to every colliery in the district which was required to be worked, or to revert to the original state of affairs of having a pumping-station in almost every colliery. This was altogether a position which it was impossible to contemplate either from an engineering or financial standpoint.

Seeing that the water has been reduced from 36,000,000 gallons per day in 1873 to 9,000,000 gallons in 1898, it might be reasonably argued that this should have been a sufficient reduction to enable the revenue from rates to pay for the pumping, and also interest and sinking fund on the capital expended. Unfortunately, from a drainage standpoint, many causes have arisen, such as the drowning of the mines themselves, the competition of coal from other districts, the economy in the use of coal, reducing the demand, and the abandonment of ironstone-working, to bring about a diminution in the output of the Tipton district from 2,660,000 tons in 1873 to 600,000 tons at the present time. If these figures are divided into the water pumped, as given above, it will be seen that 22 tons of water were pumped in 1873 to 1 ton of coal or other mineral; and that in 1898, notwithstanding the great reduction in the water, the Commissioners' engines are pumping 24 tons of water to 1 ton of mineral, while if the water raised by private pumping-engines is added the proportion is 28½ tons of water raised per 1 ton of mineral.

As regards the 9,000,000 gallons per day, the water at present to be pumped, it may be quite feasible to deal with this quantity with a smaller number of pumping plants, say six, but quite impossible for the revenue to cope with the extra expense which would arise from the multiplication of stations, although pumping only the same quantity of water.

Having clearly established the fact that the water must be dealt with at a larger number of places, the only way to bring down the cost of working an increased number of stations within the range of the revenue is by some means, not before available, to diminish the quantity of water that daily finds its way to the mines from the surface, and it is the possibility of accomplishing this which has given rise to the scheme which forms the subject of this paper.

During the time that this deadlock has presented itself with all its difficulties, the Midland Electric Corporation for Power Distribution, Limited, gave notice to eighteen local authorities, all of which were in the South Staffordshire mines-drainage area, of its intention to apply to the Board of Trade for an order to supply electrical energy for lighting and power purposes. The opposition which the company received has

been removed so far as the twelve local authorities are concerned, which practically form the whole of the Tipton district mines-drainage area, and the Act has received the royal assent this session.

Having secured the prospect of an early supply of electric energy at a cheap rate, the scheme for the extended drainage of the low-lying portion of the surface became feasible. All the area of the Tipton district has been re-examined for suitable places for surface-pumps, and fifty sites have been selected and surveys made for delivery-channels to convey the water pumped to some existing watercourse.

It is needless to describe each of the places selected except in general terms, but an idea of them and their relation to the rest of the surface-works in the Tipton district is shown on the map (Plate IX.). The deep-mines pumps are shown by black spots. The surface-streams are shown, and the area capable of being drained by gravity is already more or less completely dealt with by surface-works, which may be extended to reach more broken areas, but not in connexion with electric pumping, and therefore needing no mention in this paper. The proposed electric surface-pumping-engines are shown by rings.

The line of wires to bring the electric current to each pumping-station will depend on the position of the main lines put down by the electric-power company for general distribution.

The selection of the suitable stations for electrically-driven pumps can be suggested only by those intimately acquainted with the ground, but the designs for the electric-power pumps may be open to a great variety of suggestions, and as it is rather a new form of work to accomplish there is here ample scope for engineering skill and mechanical fitness.

Although the quantity of surface-water to be diverted from the mines is 3,000,000 gallons per day on the average, the pumps proposed would lift on emergency 25,000,000 gallons per day in storm time, when their help would be of the greatest advantage. The exact pattern of these pumps has not been settled; but now that centrifugal pumps are made to run at very great speeds, there should be no difficulty in obtaining a pump and motor of such simple construction that it could be set at work by the throwing over of a lever when the water in the receptacle rises to the arranged height, and could be shut off when the receptacle is empty. These pumps would be required to raise water only to heights of 10, 15, or 20 feet, and it is impossible to over-estimate their value, especially in storm time, in preventing water from going down into the mines to be lifted thence to heights of 400 to 600 feet.

It is wellknown throughout the coal-field that water travels out of sight frequently for great distances between the level of the original surface of the country and the top of the artificial mounds which have been thrown up by the collieries and ironworks. This water will now be intercepted by the proposed electric pumps, and the drains connected with them, before it finds places where it can get down into the mines. Water also flows into the Tipton district from the high ground beyond the district-boundaries, not shown on the map (Plate IX.).

The sites selected for electric pumps vary considerably, and will have to be dealt with differently, according to circumstances. A few typical descriptions may be of interest.

A.—Where there are at present steam-pumps, pumps worked by electricity will be substituted, and in consequence each place will produce greater effects than with the present steam-pumps, as they will be automatic, and may all be set to work simultaneously after a storm, instead of waiting as with the steam-pump until the attendant can work them in turn. They may also continue at work night and day for some days together.

B.—The stations now used for periodical visits of portable pumps will also be fitted with automatic electric motors and pumps, and the swags near them will be kept permanently low, instead of being only visited at considerable intervals of time, and thus more effectually prevent the percolation of water into the mines. This must be great, as the swags gradually fill, and near the highest level.

C.—Other stations will be placed where the old surface is still visible, in places between the pit-mounds, or known to exist under the pit-mounds, and to be reached by shallow pits, or where old pits now letting in the surface-water could be filled up to the place where the water enters, and an electric pump fixed at that level.

D.—There are old limestone-quarries in the high ground south and west of the Tipton district, which were drained, when worked, by special engines or by waterworks engines now disused; and these quarries now form funnels of large extent to catch the rainfall. Some fill up and overflow to the surface-streams, but the quantity thus flowing is so small that it cannot represent that due to the rainfall on the large surface, so that it is nearly certain that much water finds its way through lower outlets into the mines. There are canal-arms into some of these limestone-mines, and no doubt they were tolerably water-tight when in use, but now that the water rises many feet above their level, it must increase the chances of escape into the mines. These would be most awkward places

for steam-pumps and for the formation of roads to them for the delivery of coal or other fuel, but comparatively easy and simple of access for electric pumps. Many clay-holes exist, also coal-openworks for shallow seams, and stone-quarries, all of which form collecting funnels for rainfall, and if, as is often the case, old pits exist in the bottom of them, they empty themselves direct into the mines.

E.—As it was necessary to embank many of the main brooks, and also the lower ends of the streams joining them, much of the old surface is left on each side, where it is much broken, but at too low a level to drain into any outfall but the mines, and many of the sites for electric pumps will be selected in such places.

F.—The same effect is produced when canals are kept up to the proper level and the ground is sunk on the upper or off side. In many places these are drained by pipes under the canals. But these are costly, and involve annual payments for easement, so that the use of electric pumps should prove less costly.

G.—In the majority of cases, large areas have sunk owing to mining operations, so that streams had to be deepened; but this could not be done sufficiently to reach all the low places, and catch-grips will have to be arranged to surround them, and electric-power pumps used to lift the water from the rest of the low area.

H.—Some regions where the soil is sandy have caused a good deal of trouble in the past, both in maintaining streams, canals and canal-basins; but further effort will be made to take puddled watercourses at as low a level as possible, and to lift the water from the lowest ground by electric pumps, and in some cases these will drain from the bottom of the sandbeds somewhat below the ground-surface.

I.—The surface-streams have been used in many places as common sewers, and have become blocked with sewage, rubbish and road-silt. This is of course much more troublesome if they are also disturbed by mining operations, as the dirty water flows out on to bad ground too low to be removed without pumping.

J.—Other areas have been sunk by mining operations, partly covered by pit-mounds, and the spaces levelled up by town-refuse, regardless of the drainage, because the owners are satisfied if they get rid of the water, and have no interest in the mines.

The peculiar and unique position of the district has been so far explained as to enable the facts to be realized. A great deal has been done in the past, both on the surface and underground, and much valuable coal rescued, but more remains to be unwatered.

Any water that can be dealt with at the surface is so clear and great a gain to the mines, by saving pumping from so great a depth, that it is well worth a further attempt to accomplish it; and the near approach of electric power available for surface-pumping seems to offer a reasonable, safe and ready help.

Mr. M. H. Mills (Mansfield) drew attention to the large number of places distributed over an extensive area at which the electric power would be supplied, and wished that the authors of the paper had been able to give the members more information as to the amount of power that they expected would be required. He also enquired whether any arrangement had been made as to the cost of the supply of the electric power, and whether the commissioners had power to lay the cable over private property without payment. There was no doubt that the proposed scheme was a very valuable one and applicable in other cases, if they could obtain electric power from a central station. The members were aware that large areas of coal had been lost in South Staffordshire in consequence of the water difficulty, and probably some of that coal could be recovered by the new scheme.

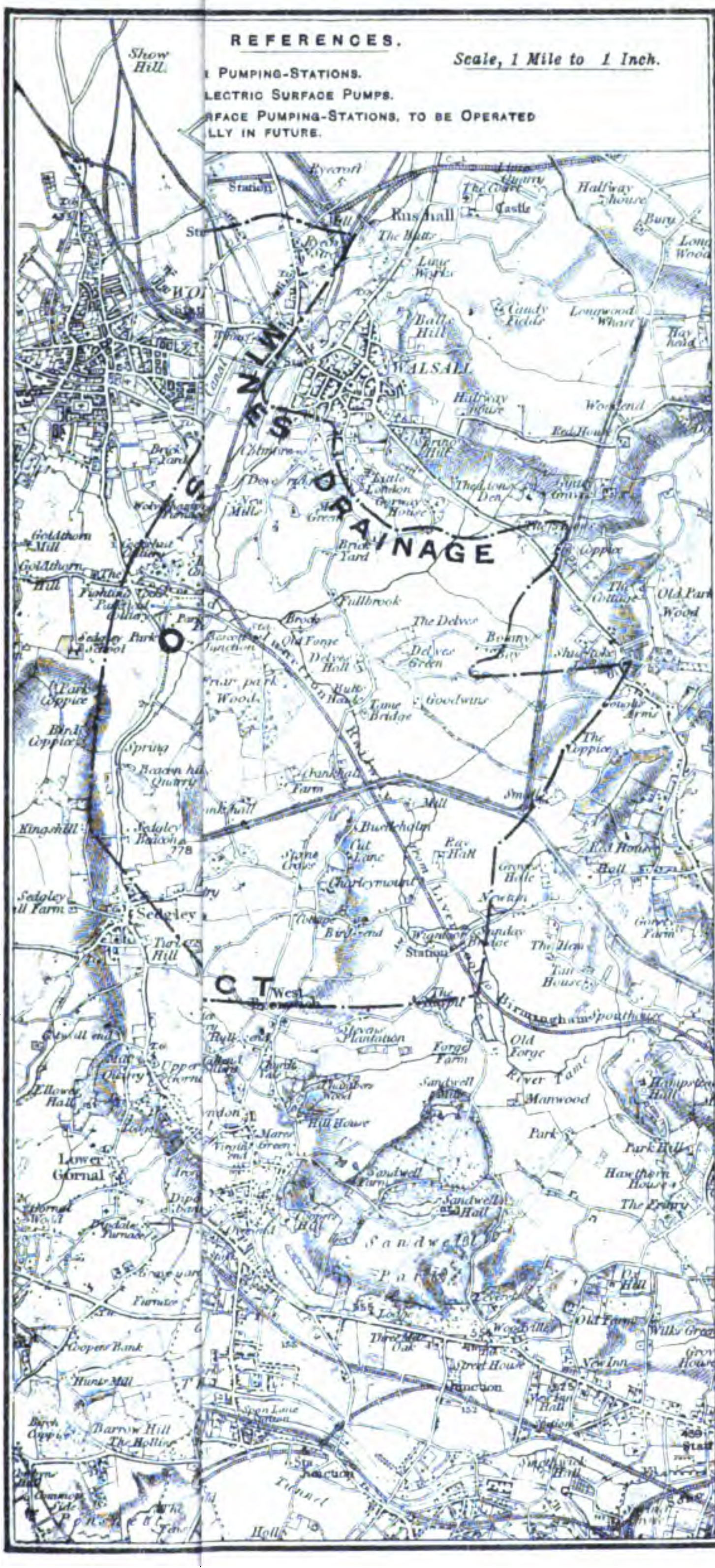
Mr. W. Spencer (Leicester) asked what was the cost of pumping with the present plant, say, 1,000 gallons per minute to a height of 100 feet.

Mr. J. L. Hedley (H.M. Inspector of Mines, Newcastle-upon-Tyne) asked whether any reserve power would be provided in the shape of steam, in case of failure of the electric plant.

Mr. W. N. Atkinson (H.M. Inspector of Mines, Newcastle-under-Lyme) asked for an explanation with reference to the relieving of the coal in the old pounds, one of which occurred at a depth of about 102 feet. He did not see how any amount of surface-pumping was going to release the coal under such circumstances.

Prof. H. Louis (Newcastle-upon-Tyne) asked how it was proposed to deal with the outflowing water.

Mr. R. Holiday (Pontefract) asked to what height the water would be lifted, what was the power of the motors, and whether they would have to run for long periods. The automatic starting of so many motors and pumps would be difficult. It would be interesting to know


REFERENCES.
Scale, 1 Mile to 1 Inch.
PUMPING-STATIONS.
LECTRIC SURFACE PUMPS.
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DRAINAGE
WALSALL
Rushall
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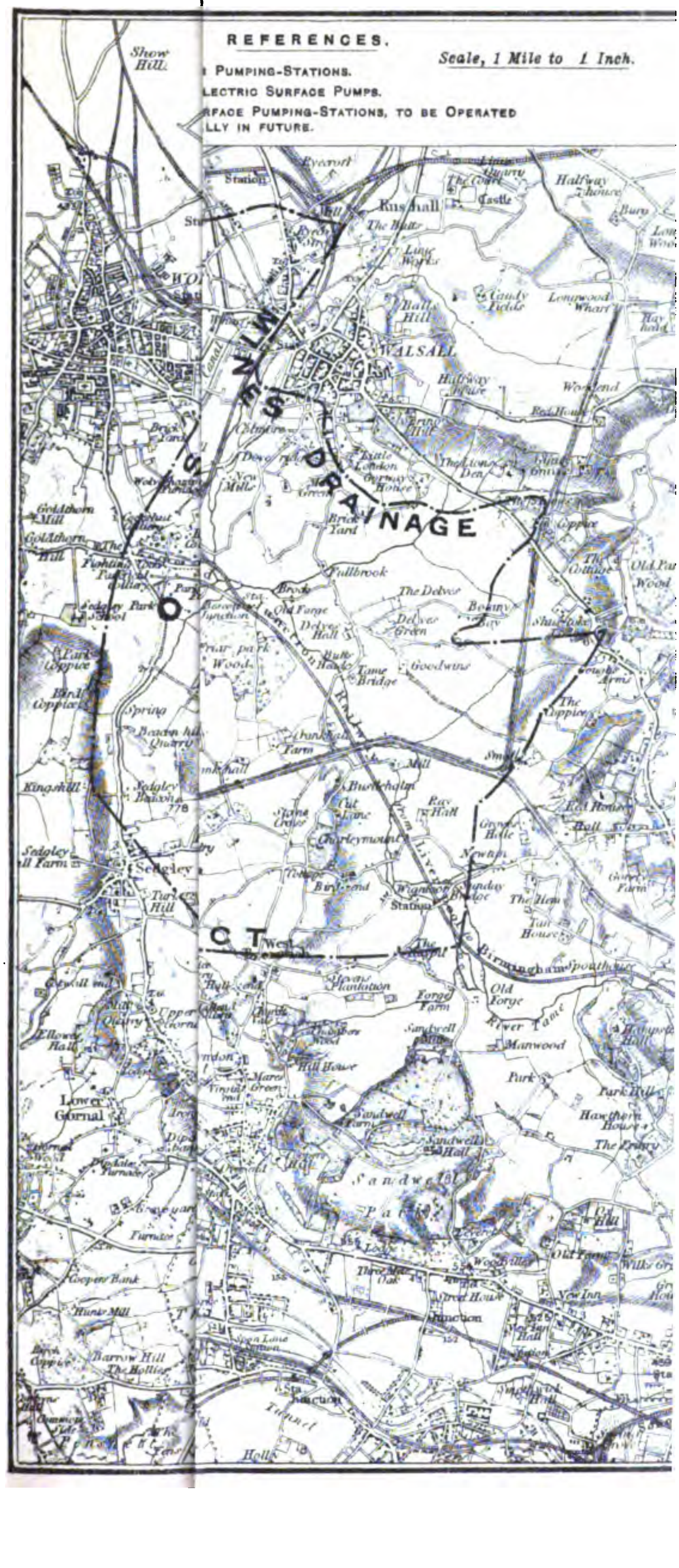
on "The South Staffordshire"



at what intervals they would be inspected, as if they were left for long periods he was afraid that there would be insulation and other troubles. In collieries, such machines were usually inspected every 24 hours.

Mr. C. C. Leach (Seghill) asked what class of pump would be used.

Mr. Henry Davey (London) was of opinion that the authors of the paper had not sufficiently emphasized the great advantage of the proposed scheme of electric distribution for the particular requirements of the area to be drained. The establishment of electric-power stations in the district seemed to offer an advantage which could not be well neglected. It seemed to him to be essential to the system of surface-drainage, because he could not imagine any other form of power to be applied which could be so advantageous, as each individual station required such a very small amount of power, probably not exceeding 3 horsepower. He thought that the authors of the paper were very wise in selecting that method, because obviously it could be done very much cheaper by electricity than by any other system which had presented itself.

Mr. John Gerrard (H.M. Inspector of Mines, Manchester) said he was sure that the members would all look forward to the completion of the work with great interest, and it was clear that they would learn much that would be of service to them in dealing with water in other districts.

The Rev. G. M. Capell (Passenham) said that the use of motors connected to centrifugal pumps was one of the new features which had not been sufficiently brought to the front. Centrifugal pumps in series were now forcing water to heights of 150 feet. He thought that with the use of electric power it would be possible to erect pumping stations both for small and high lifts without the inconvenience of erecting large buildings and machinery, which was necessary under ordinary conditions. Another advantage of the use of centrifugal pumps was that they dealt with a large quantity of water in a very short space of time—a quantity which would be quite impossible to deal with by plunger-pumps. He therefore thought that the application of the centrifugal pump to the particular purpose for which it was to be applied in that district was a step in advance, and one which might be used with great benefit in other districts of a similar character. The question of the automatic starting of the electric motor seemed to be one which ought not to present any particular difficulty, because

the electric current was always ready to do its work and the motor ready to twist round the moment that the connexion was made.

Mr. C. E. TURNER (London) suggested that the splash from the centrifugal pumps would cause a serious loss of current.

Mr. EDMUND HOWL, replying to the discussion, said that they were not proposing to put down plant larger than 2½ to 5 horsepower at any one place; as the difficulty would be in keeping the pumps going. It was suggested in the paper that they should run at the rate of 25,000,000 gallons of water per day when they were at work, but they did not expect that the average would be more than 3,000,000 gallons, so that they would not work more than one day in eight on an average. The Midland Electric Corporation had made arrangements with different local authorities that they would supply electricity at the low cost of 3d. per Board of Trade unit for the first hour and 0·825d. for the second and succeeding hours per Board of Trade unit on the demand-meter system. Electric power would be supplied to the Drainage Commissioners by that company, so that they would only have to pay for what they used. It would not be profitable for the Commissioners to erect stations for generating the electrical current when they had so cheap a supply at hand. He did not think that the danger of a breakdown in the supply need be anticipated. The Midland Electric Corporation had made arrangements with the local authorities to put wires in certain places, and under Act of Parliament the Drainage Commissioners had large powers of their own, and could do what they thought necessary. They did not think that they would have any difficulty in going over the broken areas, because they would be doing so much good to the owners that the latter would give them a free hand and be glad to grant the necessary power for laying the cables. With regard to present cost of pumping, he found that their best engine cost 3d. per lock per hundred feet (a lock being 25,000 gallons of water). If the cost of electric pumping were 4 or 5 times as much as the present system, they would still save a great deal by pumping on the surface. The Commissioners would not generate electricity themselves, but it would be bought, and, if necessary, they might place accumulators at the most important pumps to be used in case of breakdown. The electric pumps would prevent the surface-water from passing into the deep pounds, and afterwards the mine-water in the underground pounds would be removed by connecting them by means of levels with the main pumping-engines.

Mr. E. B. MARTEN said that each of the pumps was placed where they could get an open grip or water-stream, which would carry away the outflowing water. Engineers were aware that automatic pumps were being successfully worked with compressed air, and there would be no difficulty in working them equally satisfactorily with electricity.

Mr. EDMUND HOWL stated that if they lost half the electricity that was sent to them compared with the water delivered, they should consider themselves very well served. He believed that there would be no difficulty in automatically stopping and starting the electrical pumps if well housed, and he was assured that the motors would not want attention more than once or twice a week. The pumps would be put into solid boxes, and with mechanical arrangements they could prevent the water, when splashing in the centrifugal-pump, from having any contact with the dynamo.

The CHAIRMAN (Mr. George Lewis) said that the thanks of the members were due to Messrs. Marten and Howl for their very valuable paper, as in addition to the pumping question it suggested that, where possible, large generating-stations should be erected, and the electricity employed at collieries for a variety of purposes. The price of the electric current was somewhat indefinitely stated. A company in another district were preparing to supply electricity to a number of collieries at 1d. per Board of Trade unit, and he saw no reason why the South Staffordshire Mines-drainage Commissioners should not be able to purchase current at the same price.

Mr. EDMUND HOWL said that the cost would be 3d. per Board of Trade unit for the first hour and 0·825d. per unit afterwards, so that it would work out at less than 1d. per unit on 24 hours.

Mr. BENNETT H. BROUGH (London) wrote, that, in view of the clear manner in which the authors had shown the advantages likely to be derived from the use of electric power for surface pumping in the peculiar circumstances of the Tipton district, it might be of interest to refer to what was being done in Sweden, in which country a striking application of electric power for pumping purposes was recently studied by the members of the Iron and Steel Institute. At the Grängesberg iron-mines, motive power was found 7 miles from the mines at the Hellsjön water-falls, with a head of 148 feet representing a natural force of 600 horsepower. The water is conveyed by a pipe 1,575 feet long to the power-station where 6 turbines are running, to the shafts of which dynamos are directly coupled. The high-tension current is conveyed to

the mines by three 0·16 inch (4 millimetres) copper wires. A second power-station is under construction, and important water-falls, 16 miles from the mines, have this summer been purchased to meet the increased demand for power. These falls have a natural force of 3,000 horse-power. At the mines, the pumping-engines are of modern construction. The electric motor is joined to the pump, which obtains its motion by direct gearing from the motor. The pump itself has 3 cylinders and plungers. One pump is placed in the shaft at one of the mines at a depth of 690 feet, and forces 150 to 200 gallons a minute to the surface.

The Chairman (Mr. George Lewis) proposed a vote of thanks to the authors of the paper, and it was carried with acclamation.

Mr. W. Leck read the following paper on "Timbering in the Iron Ore-mines of Cumberland and Furness":—

TIMBERING IN THE IRON ORE-MINES OF CUMBERLAND AND FURNESS.

By JOHN L. HEDLEY AND WM. LECK, H.M. INSPECTORS OF MINES.

When first invited to read a paper on this subject, it appeared to the writers that there could scarcely be anything in it to interest an audience of mining-engineers. It is, however, perfectly true that what we are accustomed to see frequently becomes utterly commonplace to our own vision, and yet it may be interesting and even instructive to those differently placed.

Of the three methods in common use for supporting mining-excavations, viz.:—(1) Masonry, (2) iron or steel, and (3) timber, the latter is the only kind adopted in the iron ore-mines of Cumberland and Furness, and the annual bill for mining-timber is a serious item at practically all the mines in that portion of the mines-inspection district.

Larch and Swedish or Norwegian pine are the varieties of timber most generally used, but American pitchpine is often used for shaft-timbering.

The different methods of timbering naturally vary according to the character of the deposit to be mined. We have therefore a variety of modifications in working the following kinds of deposits, viz.:—In Furness—(*a*) Dish-like deposits, and (*b*) vein-like deposits. In Cumberland—(*c*) Partially stratified or bed-like deposits, (*d*) irregularly-shaped deposits, (*e*) vein-like deposits, and (*f*) dish-like deposits.

It is no part of our present purpose to describe the interesting geological features of these hæmatite-deposits. This subject will be found treated very exhaustively by Mr. J. D. Kendall in *The Iron-ores of Great Britain and Ireland** and also by Dr. C. Le Neve Foster in his comprehensive *Text-book of Ore and Stone Mining*.†

We have, however, thought it advisable to introduce a typical section (Fig. 1, Plate X.), illustrative of an important deposit, with the view of affording a better grasp of the subject treated of in this paper.

* Messrs. Crosby, Lockwood & Son, 1893. † Messrs. Charles Griffin & Co., 1894.

A complete description of mine-timbering should naturally begin with the shaft; but, inasmuch as the systems of shaft-timbering in general use exhibit no distinctive features, it is not proposed to enter in detail into this part of the subject. One or two circular shafts are to be found amongst very old mines, but all shafts sunk of recent years in connexion with Cumberland and Furness hæmatite-mines are rectangular. The ordinary sizes are from 10 to 12 feet long by 4 to 5 feet wide, but the newer shafts are larger.

In Furness, the system adopted for securing shafts is the common method of sets or frames; Figs. 2, 3 and 4 (Plate X.), showing the plan and section of a winze or staple-pit. The sets consist of four pieces of squared timber, *A* (Fig. 2), which are fixed in the shaft about 3 feet apart; and boards, 1 inch thick, termed "wadding-spiles," *a* (Figs. 3 and 4), are placed behind the set to keep back the loose ground.

In Cumberland, the method in general use is even more elementary. The sets or frames consist of planks, from 3 to 6 inches thick, placed close together on their edges. Each set is carefully wedged to the solid ground, and pieces of 5 or 6 inches square pitchpine, cut diagonally across, are nailed in each corner, thereby tieing all the sets firmly together.

Figs. 5, 6 and 7 (Plate X.) illustrate the method of supporting the main levels of the Furness district. Two uprights or forks, *A A* (Figs. 6 and 7), support a bar or head, *B*, placed horizontally, and these form a course of timber. The forks are faced and collared, *i.e.*, hollowed out, *e*, to allow the head to receive a full bearing-surface. To guard against side pressure, a nog, *O*, is driven into the head, close to the face of the fork.

In Cumberland, the nog is a spike-nail, but in Furness a wooden plug is used, an auger-hole being previously bored in the head to receive it.

When the side pressure is great, a plank is wedged between the forks, close up to the head, for additional security.

The head is covered by spiles, *D*, *D*, formed of deal boards, cut into regular sizes, 4 feet long, 6 inches broad, and 1 inch thick. In very heavy ground, larch spiles, 6 to 8 feet long by 3 inches thick, are used.

In soft or gravelly ore, the spiles, *H*, are driven over the last head up to the face of working, Fig. 9 (Plate X.). As the working proceeds, the spiles are driven further, until there is room for the insertion of another head. In relatively hard ore, the spiles are placed flat on the heads as shown at *D*, Fig. 9.

According to the Special Rules in force in the Furness district—

No work-person when working soft or gravelly ore shall allow the fore-breast to be more than 4 feet in advance of the timber props, nor when working ore which requires blasting, more than 6 feet in advance of the timber props.

Boards or spiles, *C*, are also placed behind the forks in tender ore, in the same way and for the same purpose as they are placed over the heads (Figs. 6 and 7, Plate X.).

Fig. 7 also illustrates the method adopted in turning-off a side working. An uptaker or cross-head, *B*, is put under the ends of the heads at the side from which it is intended to turn off the new place. The uptaking set usually embraces four heads, the forks of the two central heads being removed after the uptaker or cross set, *A B A*, is firmly fixed in position. The cross-section (Fig. 6) shows an end view of the uptaker and the timbering of the cross-drift.

The drifts are usually driven to allow of the use of 9 feet heads and 7 feet forks.

In dealing with veins or ginnels a different system of timbering is necessarily adopted.

In Lancashire, the ore in these ginnels is generally cut off by a hard limestone-roof, and as this roof does not readily collapse or crush, it not infrequently happens that height after height of the ore is taken away without the roof following. In cases of this description, we have therefore (except for the timber which is put in) huge empty chambers, which are among the most difficult of mining problems to work safely and satisfactorily.

When the veins are narrow, stays are inserted from side to side like headtrees, those nearest the top being covered with boards and chocked up to the roof. These serve the purpose of steadying the sides or cheeks of the vein and keeping the roof secure.

In wider veins wooden pillars are built, in what Dr. Foster terms the "pigstye" system of timbering,* *i.e.*, logs laid crosswise, one above the other.

In working the softer ores of Furness, similar pillars are frequently built, the wood recovered from old workings being utilized for this purpose. In these cases the logs are generally laid close together, so as to form solid wooden pillars, which are intended to keep open special airways or travelling roads. Only a small proportion of sound timber is recovered, but much that would otherwise be useless is serviceable for the erection of these pillars.

* *Text-book of Ore and Stone Mining*, by Dr. C. Le Neve Foster, 1894, page 234.

Passing along the drift, the timbering of which has been described, we arrive at one of the vertical rises, Figs. 8, 9, 10, 11, 12 and 13 (Plate X.). These rises are a special feature of the Furness mines, and with one important exception are not adopted in the same systematic way in Cumberland. The exception is Hodbarrow, where a dish-like deposit similar to those of Furness is largely worked according to Furness methods. The rise is practically a shaft, but instead of being sunk it is excavated from the bottom upwards and carefully timbered.

The rises are usually made 6 feet by 4½ feet, with two compartments, as shown in Fig. 11. One division is used as a travelling-road, in which ladders, *K*, are placed at convenient angles, and stages or platforms, *L*, are placed at regular intervals. This division is also used for bringing up timber, a small hand-winch being usually fixed at the top.

Norway timber, 5 or 6 inches square, is used in rises. The blocks, *Q*, are placed directly over each other, united at the corners with the joint shown in Fig. 12 (Plate X.). A space of 3 inches is left between the Norway blocks by inserting a small chock, *J* (Fig. 10, Plate X.). The space thus left makes it easy to insert stage-planks whenever it is necessary to execute any repairs inside the rise.

The steel rails, *M*, Figs. 9, 10 and 11 (Plate X.) are locally known as breakers. Their object, as implied by their name, is to break the fall of the iron-ore in its descent to the bottom of the hurry, the latter being the name by which the second division of the rise, *i.e.*, the ore-receptacle, is known. A larch pole, *N*, is generally used in conjunction with the steel rail, *M* (Figs. 10 and 11, Plate X.).

In the inclined hurries of Cumberland, a similar object, that of breaking the fall of the ore, is attained by the use of heavy iron swinging-doors.

The rise is taken to the top of the ore, and a first or breaking-out course of timber is inserted (Figs. 8 and 10, Plate X.). It is usual to break out at the end, in preference to the side, of the rise, as the width is less (4½ feet as compared with 6 feet); there is consequently a smaller quantity of material to remove, and less risk of dislocation of the ground, in a somewhat critical situation. A longitudinal section of the breaking-out course, and continuation of the drift is shown at, *I I*, in Fig. 10 (Plate X.).

Fig. 13 (Plate X.) is a plan of the bottom of the hurry, and a longitudinal section of the same is shown in Fig. 9 (Plate X.). These figures show an arrangement of planks whereby the exit of the hurry is narrowed, so that the iron-ore may be conveyed into the small

waggons used underground, and locally known as bogies, *G*. A door or stopper at, *E*, enables the waggoner to liberate the quantity of iron-ore required to fill each bogie. It will be noted that as the bottom of the hurry is required to support considerable weight in the shape of loose iron-ore, additional sets of timber, *F*, are placed beneath it.

In Cumberland, we have partially stratified or bed-like deposits—irregular masses and true veins, and, with the exception of the Hodbarrow mine, the system of working differs materially from that which prevails in Furness. In the first-named class, the full height of the ore is taken in the first working, whenever practicable, *i.e.*, if its thickness does not exceed 10 or 12 feet.

When a deposit of this description is too thick to work in one height, another method is adopted, which is illustrated in Figs. 14 to 19 (Plate XI.). These drawings illustrate a typical Cleator Moor deposit of partially stratified hæmatite, the iron-ore being shown about 17 feet thick. In this case, workings are laid off to take a height of 9 feet in the first instance, and are driven from 15 to 20 feet wide.

In Fig. 14 (Plate XI.), two men are at work drilling holes in the solid iron-ore. It will be observed that the timber required is simply a double row of larch props, *A*, *A*. These first workings can sometimes be driven without timber, the ore being sufficiently strong to stand without other support than the pillars which are left for that purpose.

Figs. 15 and 16 (Plate XI.) show a side view or cross-section of a level which has to deal with iron-ore of a softer nature. The term softer iron-ore, it must be understood, is merely comparative, as it is necessary to blast this iron-ore, and the working is entirely in solid ground; the roof is not, however, strong enough to stand supported by props alone, and full sets, *B B*, are inserted. In this case, the drift is driven narrower, and seldom exceeds 12 feet in width. The heads are hitched at both ends into the solid sides, *C*, *C* (Fig. 15, Plate XI.), and as the working-face gets farther away, legs are put under each end of the heads.

Large quantities of gelatine-dynamite and gelignite are used daily, and if the legs were inserted close to the face, they would frequently be blown out. This, in fact, is one of the principal difficulties to contend with when timbering ground where blasting-operations are regularly and almost continuously carried on.

Norways, *D*, *D*, *i.e.*, Norwegian or Swedish pine, 4 or 5 inches thick, and sawn into suitable lengths, are inserted over the heads, and boards, *E*, *E*, 1 inch thick, described as coverwood, are placed over the Norways.

The space between the boards and the roof is then chocked tight with short pieces of wood. In driving the first workings, the pieces of coverwood are not usually put close together, but as shown in Fig. 16 (Plate XI.).

When the boundary has been reached, the work of taking out the pillars is commenced forthwith. The pillars on the rise side and furthest from the shaft are taken first, and removed, slice by slice, as shown at *A*, *A*, in Fig. 20 (Plate X.), by methods similar to those generally adopted in coal-mines. The striking, and almost picturesque, irregularity of the pillars may be noted in passing. These hæmatite-deposits are usually intermixed with masses of stone, and the first levels, in those cases, deviate considerably from a straight line. The pillars left are consequently of varying shapes and sizes.

Timber is used as previously described, props or sets being placed as may be necessary. The pillars having been extracted, the roof iron-ore followed by the limestone crushes the timbers, and becomes practically a solid mass, which is again worked through.

It will be observed in Figs. 17, 18 and 19 (Plate XI.), that the 8 feet of roof iron-ore when broken occupies 11 feet of space, and the beds of limestone immediately above the iron-ore also occupy correspondingly increased space.

The drifts in working the second time are usually driven about 9 feet square, and two methods of timbering are shown in Figs. 17 and 18 (Plate XI.). In Fig. 17, the iron-ore being of a friable nature, it is necessary to spile closely. This is done by driving split Norways or spiles, *A*, *A*, over the last headtree and up to the face, the tail-end of the spiles being caught under the previous head. The spiles are usually about 8 feet long, 6 inches wide and 3 inches thick, and as the iron-ore is extracted, the spiles are driven forward until there is room for another head.

Short pieces of planks or boards termed listing-pieces, *B*, *B*, Figs. 17, 18 and 19, are nailed to the legs, for the purpose of steadying them until they are weighted by pressure of the ground.

Figs. 14 to 19 (Plate XI.) are really a combination of sketch and section, and have been designed with the view of conveying a clearer conception of the methods of timbering employed.

Fig. 18 is a cross-section of the roadway, and Fig. 19 (Plate XI.) a longitudinal section at the working-face. Here we have exhibited another common form of spiling. In this case, the robbery consists of rough blocks of iron-ore, the original deposit having been hard hæmatite corresponding to Fig. 14 (Plate XI.) in the first working.

The spiles, *C*, *C*, are round larch poles, about 8 feet long and 4 to 6 inches in diameter. They are driven over the head up to the face in the same way as flat spiles, the point of the spile being usually wedged under a lump as at *D*, Fig. 19 (Plate XI.). Two, three or four spiles are put over each head as required, occasionally no other covering is needed ; but generally flat boards, 1 inch thick, *E*, *E*, are laid across as shown in Figs. 18 and 19 (Plate XI.).

The second working having reached the boundary, arrangements are made to recover the 2 feet of iron-ore, *F*, *F*, *F*, which is shown as being still left over the wood (Figs. 17, 18 and 19, Plate XI.). As a rule this roof iron-ore is easily and expeditiously obtained by cutting out the centre poles between the heads, beginning with the timber nearest the boundary. If the ore be of a friable nature, and thoroughly crushed, it will readily run through the hole thus made; if it be of a harder texture, a long crow-bar, termed a proddling-bar, is used to lever down the lumps.

No attempt is made to support the limestone in this instance, beyond what is necessary to secure the safety of the workmen. To effect this object, strong spiles are driven over the headtree, after the ore has been extracted. Of course, during the last operation, considerable quantities of limestone are intermixed with the ore. As much of this stone as possible is thrown back into the abandoned workings ; but where this is not practicable, it is sent to bank.

As already stated, timber is solely used for supporting hæmatite-mining excavations in this district, and it may be remarked as somewhat strange that in the iron-producing mines some systematic attempt has not been made to supersede timber, at any rate to some extent, by the use of iron or steel.

Without entering into the general question of timber *versus* iron or steel for pit purposes, and conceding that in these mines iron or steel props or girders could not be used exclusively, there can be little doubt that, in many cases, their adoption would be of appreciable advantage.

Dry rot is a serious factor in curtailing the life of mining timber, but practically nothing is attempted to stop the ravages of this insidious and destructive enemy. In addition, the presence of very dry timber in the mine entails a continual risk of fire, and the disastrous effects of fires in and about mines have been too often witnessed to need emphasis.

The remarks and recommendations of Dr. C. Le Neve Foster in his recent report on the Snaefell disaster* may very appropriately be referred to in this connexion. Dealing with the prevention of fire, he states

* *Reports on the Circumstances attending an Underground Fire which Occurred at the Snaefell Lead-mine*, 1898.

that he "would try to arrive at the desired end by one of two methods: (1) rendering timber non-flammable, *i.e.*, not easily ignitible; or, better, (2) replacing it by non-combustible materials such as masonry, brick-work, concrete, iron, or steel."*

To achieve the first-named object, Dr. Foster recommends the Henry Aitken† method of impregnating the timber with hygroscopic salts. Timber treated in this way is said to be not only difficult to ignite, but is also rendered free from the attack of dry rot; so that two of the dangers usually regarded as inseparable from the use of timber in dry mines appear to be dealt with very satisfactorily by this process.

In conclusion, the thanks of the writers are due and are hereby tendered to the Barrow Hæmatite Steel Company, Limited, the Hodbarrow Mining Company, Limited, and Montreal Mines for the diagrams which they kindly prepared to illustrate the methods of timbering in use in Furness and Cumberland respectively.

Prof. H. LOUIS (Newcastle-upon-Tyne) regretted that the authors had not expressed their opinion as to the method of using a forkprop and round cap employed so largely in that district. That system was invariably adopted in the Cumberland iron-mines, and he thought that it was a method which could not be too strongly condemned. It was obvious that unless the prop was hollowed out to the exact radius of the section of the cap, the prop might be split. Members who had seen Cornish and Cumberland methods of timbering could not doubt that the Cornish was the superior method. He would like to know whether any of the methods adopted in some of the large American ironstone-regions had been tried with advantage for removing a slice of 8 or 9 feet in thickness, and running in barren rock from the surface to fill up the spaces as the iron-ore was taken away. There had been many experiments in America, and it was found to be the cheapest and best method of working.

Mr. W. SPENCER (Leicester) remarked that limestone sometimes formed a good roof, and if so why was part of the ore left to be taken out afterwards?

Mr. H. R. HEWITT (H.M. Inspector of Mines, Derby) thought that the method of timbering described would be insufficient in shafts of great depth, and would be glad if the authors would give the depths of the shafts and say whether the sides were strong enough to secure safety.

* *Reports on the Circumstances attending an Underground Fire which Occurred at the Snaefell Lead-mine*, 1898.

† *Patent Specification*, No. 13,749, August 31st, 1889; and *Trans. Inst. M.E.*, vol. x., page 531.

IMBERING OF RISES AND LEVELS.

Scale, 8 Feet to 1 Inch.

OF FIG. 10.

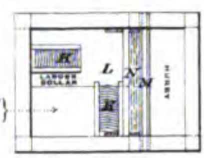


FIG. 11.—PLAN.

Z OF FIG. 13.

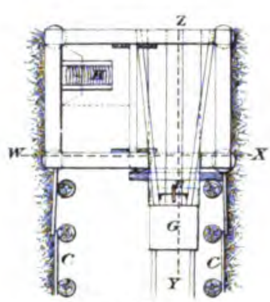


FIG. 13.—PLAN.

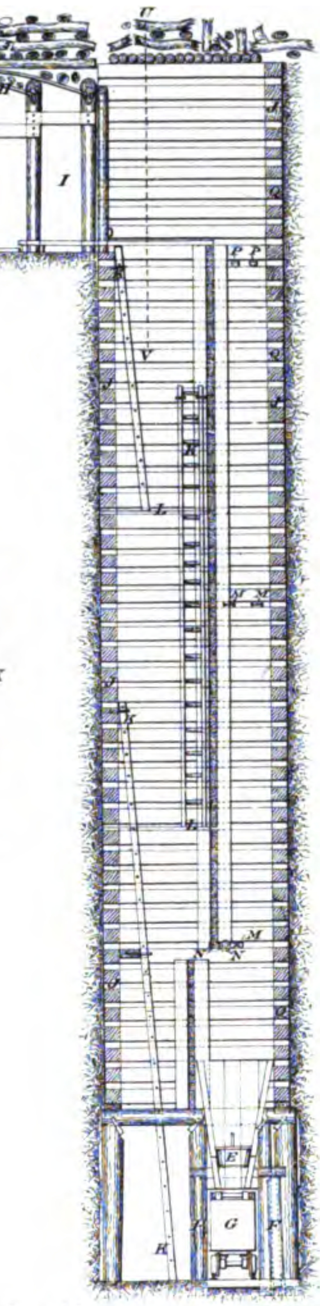


FIG. 10.—SECTION ON LINE W X OF FIG. 13.

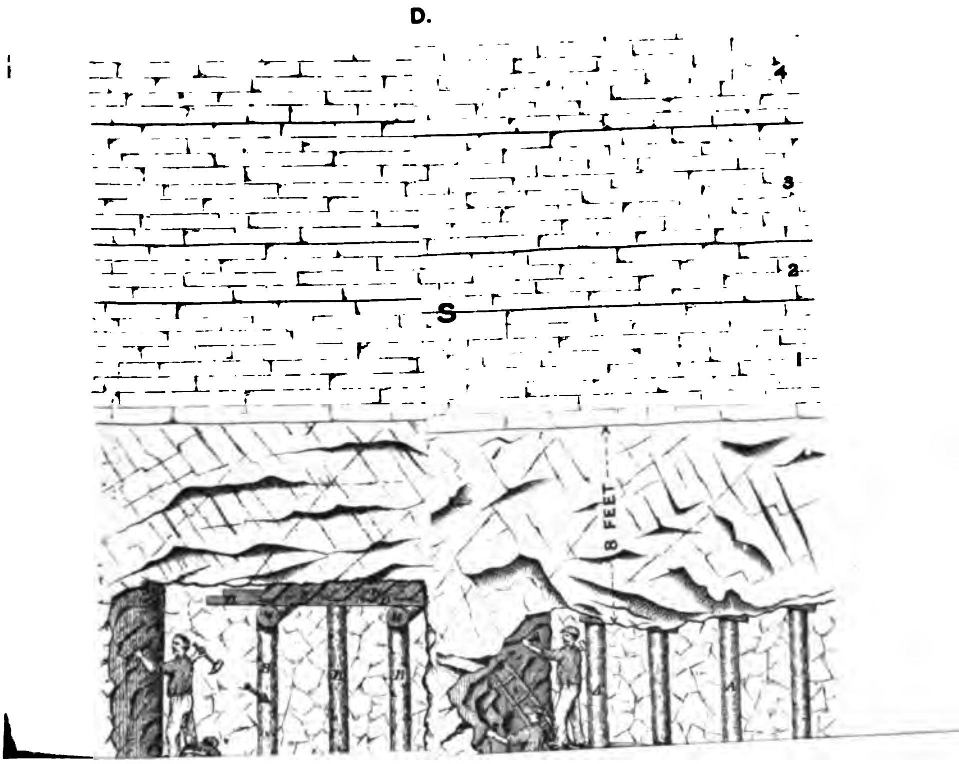
FIG. 12.

20 —PLAN.

Andw Reid & Compy Ltd Newcastle on Tyne

Institution of Mining Engineers
Transactions 18

To illustrate Mess^rs J.L. Hes of Cumberland and Furness".



Mr. A. H. Stokes (H.M. Inspector of Mines, Derby) stated that similar methods of timbering were carried out in the lead-mines of Derbyshire.

Mr. J. L. Hedley (Newcastle-upon-Tyne), replying to the discussion, stated that the method of cutting the top of the prop described in the paper was advantageous on account of the weight and the subsidence of the ground above. The American system of timbering had been tried at the Hodbarrow iron-mine in Cumberland, where the deposit was about 120 feet thick, but the system had now been abandoned. At another mine in Lancashire, where there was a similar deposit, the system was not adopted, as they did not know how far the deposit extended downwards. The depth of the shafts varied, and at one mine a depth of 900 feet had been attained without reaching the bottom of the deposit. He might say that Cornish miners, who were largely employed, always adopted the Cumberland method of setting the timber.

Mr. Arthur Hassam (Maryport) wrote, that the question of timbering in mines was one of such great importance, that the thanks of the members were due to the writers for bringing the matter forward in so able and interesting a paper. There was much which the coal-miner might learn from the application of the various methods of supporting the roof and sides in ore-mines, where the enormous extent of the mineral mass, the want of stratification, and the frequent absence of cohesion, necessitated very great skill and ingenuity in fixing adequate supports. Sometime ago it was his privilege to visit, in company with Mr. Leck, several of the mines referred to, and he was much struck with the great skill of the ore-miners in dealing with, and fixing the great logs of larch and pine ; and with the clever spiling, in driving workings in gravelly ores. But, perhaps, the most striking point of interest was the method practised at Hodbarrow iron-mines, of working a dish-like deposit of hæmatite from the base upwards, by the building up of successive square sets of heavy pitchpine, as shown and described by the authors. The method of jointing was very ingenious, and each piece of wood was cut to template by special machinery erected on the surface. The manager stated that the method was highly successful, where the ore was hard, but that it would not answer in soft ores. The system of boring holes in the heads, and fixing nogs to support the forks or legs was simple and effective, but it seemed to have the effect of weakening the head. He suggested that a better plan would be either to nail brackets on to the head or to fix a cross stay. Very little British

grown timber appeared to be used in the iron-mines except larch, and a lesson in this respect might be taken by many colliery owners and managers. Other varieties of English grown timber were used in coal-mines, with very indifferent results. Most mining engineers will be of the same opinion as the authors, as to the superiority of steel girders to timber for mining supports—at all events for permanent or road-work, if not for face-work. It took up less space, was stronger and more durable, and could be used over and over again. The first cost was against its use, but its advantages and final economy and efficiency were so evident that its use was gradually but surely extending every day. He could fully endorse the writers' remarks as to the danger of fire arising from the use of timber in mines. In several instances of gob-fire in coal-mines, which had come under his notice, the seat of ignition had been timber, which had been left behind in the goaves. The original heating had doubtless been due to the chemical action of the minerals, but the dry timber had formed a very ready combustible, probably at a much lower temperature than would have been necessary to ignite the surrounding mineral, notwithstanding that the latter was the active agent. Further, apart from the danger of fire, the decomposition of timber gave rise to explosive gases, and he believed that several slight explosions of gas generated in this manner had occurred in metalliferous mines. It would be interesting to know the cost of the timber used per cubic yard of ore extracted, both in the spiling systems, where larch was the usual timber, and in the square-pine set system as adopted at the Hodbarrow mines.

The CHAIRMAN (Mr. George Lewis), in proposing a vote of thanks to the authors of the paper, said that the question of timbering seemed to give rise to differences of opinion. In various districts, certain systems of timbering had been employed for generations for reasons which were not easily explained. But he thought that the workmen knew more about their particular district and its requirements than did those who casually visited it. He was therefore loth to condemn a system of timbering about which he had had no opportunity of ascertaining its utility. It did not appear desirable to place a round piece of timber over the square end of a prop, but there might be some particular reason which would cause him to alter his opinion.

The resolution of thanks was adopted.

Mr. Wm. M. Brewer's paper on "Prospecting in British Columbia," was read as follows :—

PROSPECTING IN BRITISH COLUMBIA.

By WM. M. BREWER, Victoria, British Columbia.

During the past spring and summer, the writer has been engaged in prospecting and exploring some sections of British Columbia, of which but little has been known up to the present time. Although it is true that the Fraser river placer-diggings were worked as early as about 1856 by miners who came from California, yet it is also true that no attention had been paid to quartz-mining in the country drained by this river and its tributaries until within the past few years. Even to-day, so extensive is the territory lying between the line of the Canadian Pacific railway and the northern boundary of the province, that except along a few streams, no prospecting has been done.

But before commencing a description of the territory visited by the writer, a few suggestions of a practical nature relative to outfits and mode of travelling may not be out of place. One important feature in this connexion to which due consideration should be given is the fact that nature has so distributed the waterways that in the past most of the travelling has been by canoe. Except in the vicinity of towns, there are no waggon-roads, and often no trails. Those which do exist were built for the convenience of the Cariboo miners many years ago, and have been kept up because several mining-camps of importance are located on the route north from Ashcroft on the Canadian Pacific railway to Barkerville, in the centre of the Cariboo district. This stage road is about 300 miles long, and trails branch off from it in many directions to the camps occupied nowadays either by mining companies engaged in hydraulicking or by placer-miners.

When this condition is given due consideration, unless the prospector proposes to follow the beaten track along the highway just referred to, it can be readily seen that he must be prepared to rough it in every sense of the word. If he really desires to explore virgin territory he will do well to carry as light an outfit as possible, and hire *Siwashes*, as the Indians are called, either to transport him and his outfit by canoe along the lakes and streams, or to pack the outfit while he walks through passes and across the mountains to explore the country drained by these watercourses.

Pack-animals are of little service, for two reasons :—(1) the scarcity of feed, except in a few localities ; and (2) their inability to travel except along beaten trails.

Another advantage in hiring Indians is the fact that not only do they know the country thoroughly, but very many of them, as the writer has discovered, have very good notions of the character of the rock, and during their hunting-trips locate leads and ledges of mineral bearing quartz. To these they will often guide white men who hire them, without demanding any additional remuneration. As a matter of fact, all the high-grade quartz which has been found in this territory, north of the railway, was originally discovered by Indians or half-breeds.

The Hudson Bay Company, several years ago, originated the "Chinook jargon" in order that all the northern Indians might speak one language, which the whites could readily learn. The original languages used by the different tribes vary so much that to-day the Douglas tribe, inhabiting the country along the Lillooet river, cannot understand the Chilcotins who live only a comparatively short distance north, or the Squamish tribe living on the coast at the head of Howe sound, and *vice versa*. But all can use "Chinook" and consequently understand each other. Dictionaries of this language can be purchased at nearly any book-store in the province, and a white-man can familiarize himself with it in a few weeks sufficiently to converse with any of those Indians.

In dealing with them it is requisite to exercise tact and diplomacy, or one will be most unmercifully cheated and imposed upon. One also should be a good judge of character, so as to be able to select good Indians from bad ones, and it will then be found that the best are none too good or reliable.

There is one good trait possessed by the Douglas Indians at least, that is honesty. It is due to the just and impartial administration of good laws made for the treatment of the Indians by the Dominion government that to-day they are self-supporting, fairly industrious, and, as a rule, reliable. Therefore, the explorer or prospector need have no hesitation about hiring them for guides. They are also expert canoemen and know the waters of their territory thoroughly, which is very essential, because all the rivers are so full of rapids that the average white man would soon come to grief if he attempted canoe-trips alone.

Only recently, the writer drifted down 30 miles of the Upper Lillooet river in 3½ hours. The trip up the same distance occupied 3 days, and required the utmost efforts of two Indians with the assistance at times of three white men.

The territory which the writer proposes to discuss in this paper is that drained by the Upper Lillooet river, and also that lying north of that river towards Bridge river. According to the published maps of the province, the Upper Lillooet river is a small insignificant stream. In reality, it is about 50 miles in length below the forks, but thence up stream the writer could gain no reliable information as to the length of each fork. Owing to the high water and swift current, he was only able during a recent trip to reach a point about 30 miles above the mouth. Later in the season though, when the water falls to its normal level, he purposes making another effort to reach some hot springs which the Indians report as occurring about 4 miles above the forks, and on the southern prong.

There are four routes which reach the section dealt with in this paper:—(1) That travelled by the writer leaves the Canadian Pacific railway at Agassiz station, 65 miles east of Vancouver, thence by stage to the Harrison hot-springs, at the foot of Harrison lake; up the lake to its head at the mouth of the Lillooet river by steamer, a distance of about 50 miles; thence 30 miles by waggon-road up the river to the foot of Tennasse lake; and up this lake to its head, a distance of 6 miles by canoe. There the river, very swift and comparatively narrow, is encountered again, and the traveller takes the trail-portage for 2 miles to the foot of Lillooet lake; up that by canoe, a distance of 24 miles, to the mouth of the Upper Lillooet river to the Pemberton Meadows, the name given to the river-valley, because of its extent and the abundant growth of natural grasses. A pony-trail has been cut around both of these lakes, so that the entire trip can be made from the head of Harrison lake by land, but the canoe is much more comfortable, especially when an outfit is being taken, because the trail is rarely used for packing, being rough, rocky and mountainous.

(2) This route leaves the Canadian Pacific railway at Lytton station, at the confluence of the Thompson and Fraser rivers; thence by stage to Lillooet, 40 miles distant on the Fraser river; thence by canoe up Seton lake, 18 miles long; then across a portage, 1½ miles to the foot of Anderson lake, 16 miles in length, up this by canoe to its head; thence by trail 24 miles, through the Pemberton portage to the Indian village at the Meadows, 4 miles above the mouth of the Upper Lillooet river. A good pony-trail has been cut around the northern shores of these lakes, over which loaded pack-animals can be taken with safety.

(3) The third route leaves the Canadian Pacific railway at Ashcroft station, 203 miles east of Vancouver; thence by stage to Lillooet, and from there *via* Seton and Anderson lakes, by the same route as the second route.

(4) This route leaves Vancouver by steamer or other craft, thence about 30 miles up the coast to the head of Howe sound; from this point a trail was cut several years ago, north-easterly, to the Pemberton Meadows, which it enters about 9 miles above the mouth of the Upper Lillooet river. The distance from Vancouver by this route is, the writer is reliably informed, less than 100 miles. In summer time, there is ample feed for pack- or saddle-horses, but during recent years this route has been travelled but little, even by the Indians.

As early as 1858, the British Columbian Government, then a crown colony, opened both the routes *via* Harrison lake and the Anderson and Seton lakes, for the convenience of the placer-miners going into the Cariboo district. These pioneers, who were unable to navigate the Fraser river for any great distance from the coast because of its rapids, were transported by steamer or other craft up that river as far as the mouth of the Harrison river, and during high water up that river to Harrison lake; or during low water they left the Fraser river and crossed by waggon-road to the foot of the lake. The town of Port Douglas was established at the head of Harrison lake in 1857, and flourished as a typical mining-camp until about 1874. To-day, one white man and a number of Douglas Indians are the only residents of this once important starting-point to the rich placer-diggings of the Upper Fraser and Quesnelle rivers.

From Port Douglas, the route travelled by the old-time miners was up the first route to Pemberton Meadows, thence down the Pemberton portage, Anderson and Seton lakes to Lillooet, and from that point they scattered along the Fraser river. Below the town, some of the richest placer-diggings ever worked in British Columbia were discovered more than 40 years ago.

It is not the purpose of the writer of this paper to discuss the past history of this section of the province, but he has thus briefly described the routes into the Upper Lillooet district in order that more intelligent ideas can be formed by the reader as to the geographical position of the territory.

The prevailing rock on both sides of the Lower and Upper Lillooet rivers as well as the Tennasse and Lillooet lakes is granite, the course of the river runs from north-west to south-east, and the trend of the mountains from south-east to north-west. This belt of granite has been cross-cut in many places by dykes of eruptive rock, usually diorite, diabase, or varieties of serpentine. These dykes are generally of con-

siderable extent, and fissures sometimes of extraordinary thickness occur filled with quartz carrying iron pyrites, chalcopyrite and galena. In one instance, the writer found one of these ledges of mineralized quartz to be 700 feet in thickness, its dip almost vertical and strike northwesterly. The thickness was exposed by a cross-cut made by the waters of a glacier-stream.

All the creeks in this district, as well as the Lillooet river itself, are derived from glaciers, many of which occur within comparatively short distances from the mouth of the upper river.

The topography of the country is extremely rugged beyond the limits of the wide valley of the upper river. The mountains rise to altitudes of from 1,000 to 5,000 feet above the level of the valley. The sides, owing to snow and rock-slides, especially towards the summits, are extremely precipitous, and climbing is often dangerous on account of falling boulders.

Judging from trips made by the writer northward from the river, the belt of granite is about 4 or 5 miles wide on that side. Beyond, occurs a belt of diorite and other pyroxene-rocks, and beyond that metamorphosed argillites and schists.

During the season of 1897, a large number of prospectors worked in the country between Port Douglas and Tennasse lake, but very few continued their explorations beyond the foot of that lake. It was during this season, that discoveries of gold-bearing quartz were made on Fire mountain. This mountain rises west of Port Douglas, and the rich assays reported created quite an excitement, but failure to make sales by the locators, and lack of means to properly develop the claims caused an abatement of the excitement, so that during the present year but comparatively little work has been going on in the camp. The government, however, made an appropriation to build roadways, so as to enable mine-owners to take in machinery and supplies at a more moderate cost than heretofore.

The first stampede to Fire mountain was so early in the spring that several feet of snow covered the ground, but this did not hinder the prospectors from locating claims, and in a short time every foot of the mountain and contiguous territory was staked. Owing to this fact, the writer did not visit the mountains, but continued on up the river in order to reach virgin ground, which was found above the foot of Tennasse lake.

Along the shores of both Tennasse and Lillooet lakes there is but little evidence of the occurrence of ore, until the upper end of the

latter is reached, where occur some of the eruptive dykes to which the writer has already referred. The heavy iron-capping, so common in the Kootenay districts, is seen in some of these dykes, but so far no discoveries of quartz-ledges have been reported. The fact is that no prospecting has been done through the country tributary to either shore of the lakes. The rugged mountains are practically inaccessible, at present, except to prospectors who pack their outfits on their backs. No trails have been cut except along the northern shore, and granite is a very unpopular formation with the average prospector, especially in this northern territory, because most of them are old placer-miners, and more accustomed to work in slates and schists.

Towards the east, along the Fraser river, in the vicinity of Lillooet, the prospectors all seek free-milling quartz, and as most of them are old placer-miners, they have been year after year prospecting in the vicinity of the Fraser river to find, if possible, some of the ledges in which the placer-gold was originally deposited. The explorations from this section have, until 1897, been confined to the argillite-formation on Cayoosh creek, and the immediate vicinity of Lillooet. During that season, a stampede was started to Upper Bridge river, its southern fork, and Cadwallader creek, one of its tributaries, because of the remarkably rich specimens of quartz showing particles of free gold, some as large as grains of wheat, which were brought from there. Bridge river and its tributaries had for years past been favourably known, because of the placer-gold taken from them. The discovery of rich quartz in addition created a Klondike craze in miniature early in the present spring, and drew attention away from other sections.

Last year, the stampeders from the vicinity of Lillooet rushed pell-mell to the Blackwater creek, which is crossed on the Pemberton portage, where some very extensive ore-bodies had been discovered. The grade was low, and the ore carried so much copper, that treatment by smelting was necessary. Capital was slow to take hold of the camp, and it died a natural death, with location-stakes set up on every available foot of ground, whether containing ore or not.

Reference to the accompanying sketch-map (Plate XII.) will explain how the prospectors from the south-east, south, and south-west have gradually approached the Pemberton Meadows, also how those from the east and north-east have done the same. But still a vast expanse of country lying between the headwaters of the Bridge and Upper Lillooet rivers, as well as from the latter westward to the coast, is to-day virgin territory.

North of this district lies the section known as the Chilcotin country, because there the tribe of Indians bearing that name, the old enemies of the Douglas and Fraser River Indians, have their reservations, hunting and trapping-grounds. Of this section, nothing is known except to a few Indians, as not one white man in a thousand amongst the old placer-miners or prospectors has ever attempted to explore it. The Chilcotins tell of vast table-lands or plateaux where bunch-grass affords excellent summer-pasture for their ponies, and which are level for miles; and of the beautiful valley of Chilcoh lake and the game abounding within the limits of their country. They have a trail from Jack's Landing on Bridge river which they travel when they occasionally visit Lillooet and the Lower Fraser rivers on trading or pleasure excursions.

These Indians bring gold-dust to the traders, but where they find it is a secret that they will not divulge.

During the present season, prospectors have been busily at work on the southern fork of Bridge river and Cadwallader creek. By the trail followed from Lillooet, the distance to this territory is about 80 miles. The route runs up Seton lake 14 miles to the Indian mission; thence northerly across the divide, the summit being 3,000 feet above the lake, but only 1,500 feet above Jack's Landing on Bridge river, 8 miles distant by the trail. This point is about 40 miles above the mouth of the river. Below the channel is cut mostly through cañons, the fall being nearly 1,500 feet in 40 miles, and consequently the current is very swift, and too dangerous to attempt to navigate in canoes. Above, the river is sluggish, the fall being very slight, and only at one point do rapids occur. Canoes and boats can come down without the slightest danger, but as there are no Indian villages above the mouth, all the travel is along the trail, which has been cut along the northern bank.

The writer recently followed this trail, hoping by the aid of an Indian guide to be able to cross from the South Fork through the mountains to the head of the Lillooet river. But the timber was too dense to cut a trail through it, unless several axe-men were employed, and the work would have occupied more time than could be devoted to it during the present season.

Although several years ago, considerable placer-gold was taken from near the mouth of Bridge river, also from Tyanchon creek, a tributary emptying into it from the north about 55 miles above the mouth, as well as from near the mouth of the South Fork, yet very little indication of mineralization occurs on the portion of Bridge river travelled by our expedition until the vicinity of South Fork is reached.

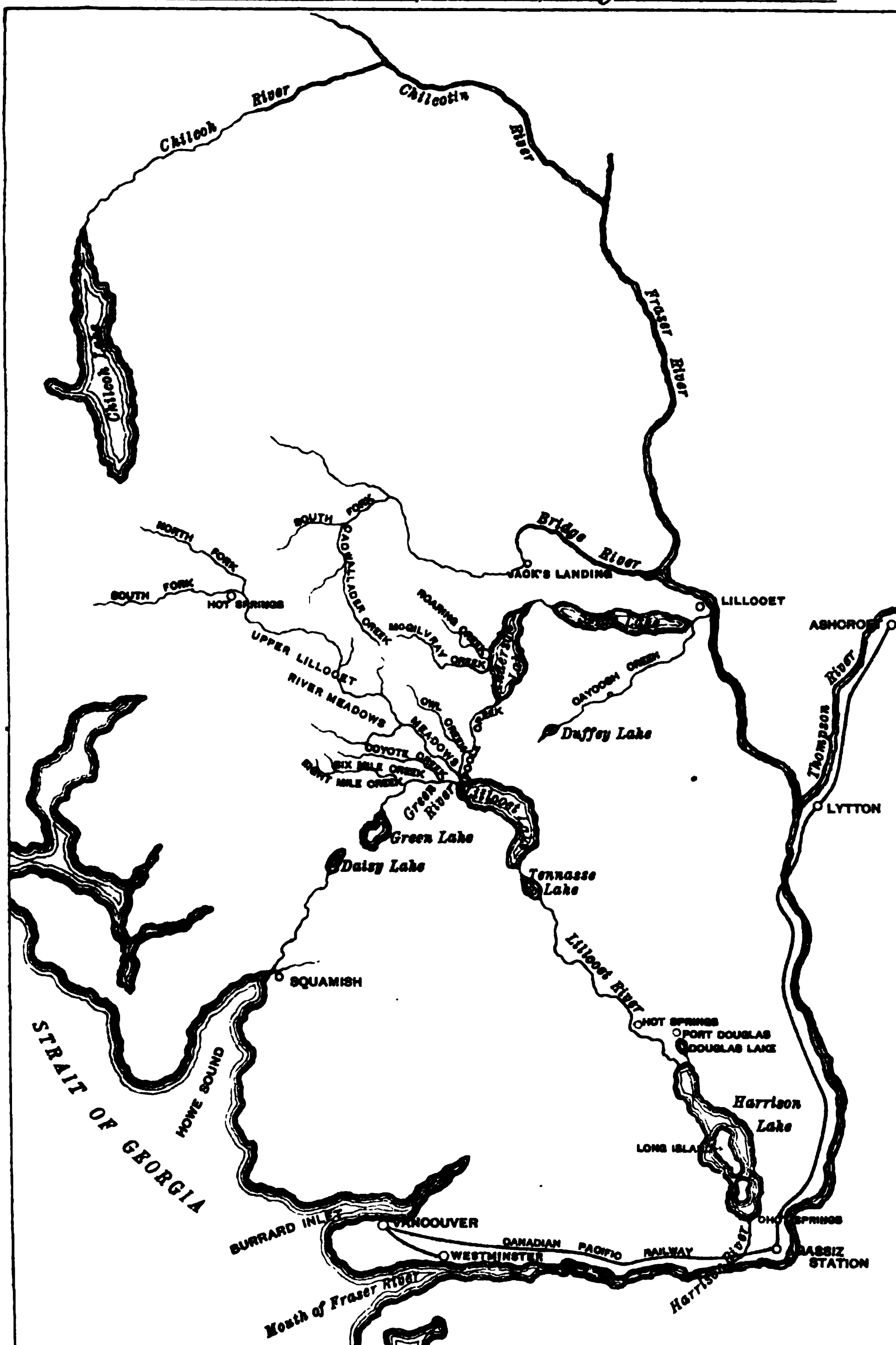
The local prospectors have been talking of the "ash-beds" which occur through the country above the mouth of the Tyanchon creek, but these are merely derived from disintegrated and decomposed gneiss and schists in which felspar has formed a very large proportion of the rock. The surface for many miles, in every direction, is covered by this disintegrated material.

While a miniature Klondike fever has raged through this section during the present season, the actual development-work accomplished has been too limited to warrant any opinion as to the future of the camp. Some very rich specimens have been brought from narrow quartz-veins, varying from a few inches to about 4 feet in thickness. These were found at and near the surface, and led to the belief that the camp would produce free-milling ore in considerable quantity. The fact that as these veins are followed, the quartz becomes refractory, or partially so, is causing disappointment, and many prospectors had, at the time of the writer's visit, left the camp to seek free-milling quartz in other sections. Some prospectors have started north towards the Chilcotin country, because the Indian trails render it much more accessible than the country in other directions.

There is one feature regarding many mining-camps in British Columbia to which mining engineers should give due consideration, and thoroughly investigate before recommending development-mining. This is the fact that ground is too often staked, and recorded for mineral claims which has not the faintest shadow of right to be considered as such. This pernicious habit is followed in nearly every newly discovered camp. The writer has already referred to staking in snow on Fire mountain, and during his trip into Bridge river camp he found stakes and location-notices on ground where no indication whatever of the occurrence of ore exists. He was reliably informed of one instance where two men located twenty claims in one day. The posts were marked according to law, but no *bona fide* discoveries were made.

Unscrupulous promoters and agents for syndicates have fostered and encouraged this practice in order to represent in glowing terms in prospectuses that the property offered to the public embraced a certain number of claims in the vicinity of some mine which had acquired value through the persistent efforts of its owners to develop its resources properly and show ore in sight. Each property in British Columbia must be judged on its own merits. Near proximity to an established mine does not give a prospect any tangible value, unless actual develop-

To illustrate Mr. Wm. M. Brewer's Paper on "Prospecting in British Columbia."



SKETCH MAP
OF
SOUTH-WESTERN BRITISH COLUMBIA,
SHOWING THE
UPPER LILLOOET RIVER AND TRIBUTARY TERRITORY.

ment has exposed its ore-body and a sufficient quantity of ore in sight has been determined. The section of the province which the writer has described in this paper is entirely new and its possibilities are unknown quantities. So far as *bonanzas* are concerned or even free-milling properties, it has not yet been demonstrated that any occur. If the extensive bodies of mineralized quartz carry even low-grade ores, they will pay to work on a large scale. They are so extensive that they may be developed into properties equally as valuable as the Homestake in Southern Dakota or the Alaska Treadwell and Alaska Mexican mines. In the writer's opinion, it will be through these ore-bodies that this district will be brought into prominence, rather than through those which are smaller though of apparently higher grade.

Water-power and timber are very plentiful throughout the territory described, and transportation is not very difficult or costly.

Large areas of well-watered agricultural land and natural pasturage in the Upper Lillooet valley, where irrigation is not necessary, as well as on the plateaux of the Chilcotin country, will eventually be improved and furnish to the miners, at reasonable cost, fresh meat, vegetables, hay, and grain. Whether the Chilcotin ranges and valleys will ever become a farming country, except so far as stock-raising is concerned, is a question for future solution, but if they should, then certainly this comparatively unknown region will develop into the granary of the province, whenever it is rendered more accessible by the building of roads connecting it with the coast.

A vote of thanks was passed to the author of the paper.

Dr. E. Gilpin's paper on "Underground Certificates in Nova Scotian Coal-mines," was read as follows :—

UNDERGROUND CERTIFICATES IN NOVA SCOTIAN COAL-MINES.

By E. GILPIN, Jun., H.M. Inspector of Mines.

In the Dominion of Canada no general provision is made by the Federal Government for education. Each province adopts the system apparently most suitable for the needs of its inhabitants. This arrangement was made at the time of confederation, in order that the privileges which each province had secured in the way of free education should not be endangered from an outside source, and possibly interfered with by an irresistible power. In Nova Scotia, almost one-third of the scanty annual provincial revenue is expended in assisting the various sections in providing educational facilities ; and this freedom of action has enabled the province to provide agricultural, horticultural and teachers' schools, and to subsidize other educational organizations.

Public attention in the province had been specially directed to coal-miners on account of the serious accidents that happened from time to time, and the struggles between capital and labour. As a result of a long and bitter strike, labour unions were formed at all the mines and federated under a general council. Many persons, even well-wishers of the men, prophesied evil from these unions ; but time, however, has shown that when the lodges have been officered by reasonable and fair-minded men the results have been favourable.

To their credit it is to be said that, through their representative, the Hon. Robert Drummond, arguments were brought to bear on the government in favour of a total change in the system of management of coal-mines. It was admitted that, as a class, the mine-managers, who generally also discharged the duties of agents, were men equal to their business ; but it was contended that the men who practically controlled and directed the underground operations were not infrequently lacking in general knowledge and of limited experience, and that important positions were given to men whose chief merit was a willingness to carry out orders. Finally, it was determined to grant certificates of service to all who had for a certain number of years filled the position of under-

ground manager or overman, and that in future any person filling these positions should be the holder of a certificate of competency. A board of examiners representing mine-owners, workmen and the mining engineering profession was formed, and local instructors were appointed in sufficient number to ensure facilities for attendance to any would-be pupils. This system was afterwards extended to include mine-managers.

As all of the candidates were required to be at least 21 years of age, and many were over that age, it was evident that the pitboy's education, often finished as he entered his teens, was not a good ground for the instructor to work upon. In order that he might not be required to impart rudimentary education, provision was made so that in all mining localities night-schools could be formed on petition by intending pupils. The district teachers and schools were utilized by the government for this purpose. These measures furnished a fairly comprehensive scheme, which has worked satisfactorily for a number of years.

Since 1882, 32 certificates of service have been granted to underground managers and overmen, and 293 certificates of competency. Fifty certificates of service and of competency have been granted to managers since 1891.

As a matter of comparison, the writer gives at the end of this paper a recent set of questions. Many workmen barely able to write, and with only an elementary knowledge of arithmetic, have passed the three successive stages, and are to-day in charge of pits, running with haulage-plants, compressed air, electric plants, etc. Thus A passed as overman in 1891, as underground manager in 1893, and as manager in 1897, and so on. Many of course have not advanced beyond the overman's certificate. Some little friction was experienced in introducing this new order of things, a friction more evident in a small province where political and personal influence could be exercised to a greater degree than would be the case in Great Britain; but now the owners of the coal-mines feel that they can select more efficient officials from those holding certificates than they could formerly from their lists of men available for promotion. At present, taking the figures already given, we have 325 men holding certificates of competency as underground managers and overmen, and last year an average of 2,144 skilled workmen were employed underground, not counting boys and labourers.

An Act was passed in 1891 (section 11, chapter 9, Acts 1891), as follows :—

Where there is a shaft or an inclined plane or level in any mine, whether for the purpose of an entrance to such mine or of a communication from one part to

another part of such mine, and persons are taken up or down or along such shaft, plane or level by means of any engine, windlass or gin driven or worked by steam or any mechanical power, or by an animal, or by manual labour, a person shall not be allowed to have charge of such engine, windlass or gin, or of any part of the machinery, ropes, chains or tackle connected therewith, unless he is a male of at least 18 years of age. Nor shall any person have charge of such engine, windlass or other hoisting apparatus, unless he has undergone an examination by a person or board to be appointed by the Governor-in-Council, and holds a certificate of competency based on said examination. Certificates of service may be granted until January 1st, 1892, and this section shall not go into operation till that date.

By this enactment, provision was made for the examination of men employed in running engines for raising and lowering persons in the coal-mines. A board of three practical mechanical engineers was appointed, and instructors were placed wherever enough pupils offered. Three grades were recognized among those passing. This division has perhaps proved too minute, and it may be found that two classes of certificates would prove enough. The author appends a set of questions fairly illustrating the tenor of the examinations.

The ground being now fairly covered as far as the underground officials and one of the most important divisions of the workmen were concerned, there remained a logical step. The safety of the workings depending as much on the intelligence of each individual workman as on the efficiency of the overmen, it is evident that any step tending to exclude undesirable or inexperienced men from the working-faces made towards strengthening the complete chain of all engaged in the extraction of coal. It is true that the carelessness or ignorance of an individual miner most often is reflected disastrously on his own shoulders, but he frequently also involves in disaster his loader or driver, or more rarely initiates a wide-spreading calamity.

However, in this province the question of securing some test of the ability of the individual miner came rather from practical considerations than from any logical outcome of the steps already taken.

In Nova Scotia, for many years, coal-mining was practically at a standstill for about four months of the year. This was due to the closing of the St. Lawrence river by ice during the winter and the enforced accumulation during the summer at all ice-bound points of the necessary winter stocks, and to the expense of keeping open the harbours and the absence of railroads to more distant markets and ports of outlet. This state of affairs has gradually changed, so that on the mainland shipments and work go on throughout the year, and it is expected in Cape Breton that trade with the United States of America will soon permit of

all winter-shipments *via* Louisburg, now connected with the Cape Breton coal-field by a colliery railroad of a higher standard than any yet constructed on this continent or in Great Britain.

This cessation of work led to many men working their little farms or lumbering in the winter, and cutting coal during the summer. Other miners stayed at the mines, and received more or less work during the winter. There were thus formed two classes of miners, and when the rush of business came in the summer, men were employed in coal-cutting, even in gaseous mines, who were certainly not experienced miners, nor likely to become so, as they looked upon their underground work merely as an interlude in their home employment.

Finally, the following amendment was made to the Mines Regulation Act of 1891, section 15, chapter 9 (sub-section to be added to section 40):—

And in no mine to which this chapter applies shall any person not now employed as a miner be "given the picks" to work as a miner unless he has been employed in a mine, in some capacity, for the space of one year. No one shall be given charge of a working-face in a mine who has not worked previously in a mine for the space of two years, nor shall any one now a miner be employed after the 1st of January to mine coal who is not a holder of a certificate of service; and no one not now a miner shall be "given the picks" to work as a miner until granted a certificate of competency after examination by the Board of Examiners appointed for the purpose of granting certificates as managers, overmen or shotfirers, or by an examining board to be hereafter appointed, who shall have power to frame laws and conditions under which said certificates shall be granted.

It was claimed, by many, that the practical result of this legislation would be a miners' close guild, and that it would become difficult to find enough men to dig coal during any sudden demand. The Act came into force on January 1st, 1892. The output that year was 1,942,780 tons, and in 1897 the output was 2,300,916 tons. So far, no trouble has been experienced in finding an ample supply of men.

The machinery for carrying out this Act is of the simplest description. A board of two men of practical experience in coal-mining is appointed at each colliery, which holds examinations and issues certificates at short intervals. Returns are made quarterly to the Department, giving the names of persons receiving certificates and the grade of certificate.

The result of the enforcement of this system of certificates has been, so far, very satisfactory. A miner of dissipated habits is liable to have his certificate cancelled by the board, or he can be dismissed by the management under the law, without incurring the resentment of his fellow-labourers. It is claimed, and the writer thinks justly, that the

educational facilities placed within reach of the miners have made them more provident and steady. The old-time drinking and disorder of pay-days is almost unknown, except among the young labourers who come to the mining districts from the country. In the mining village of Stellarton, one of the oldest in Nova Scotia, during the past year the fines for disorderly conduct were nominal.

Further, these preliminary *viva-voce* examinations have paved the way to candidates for the overman and other certificates, and, generally speaking, have impressed a sense of responsibility upon the younger miners growing up for certificates.

The following Order in Council published on December 2nd, 1892, marked the commencement of the issuing of certificates to miners :—

The persons so appointed shall form the Board of Examiners for their respective districts, and shall hold, as often as may be required, examinations, at which persons desiring certificates of competency shall present themselves. The examinations shall not be by written answers to questions, unless so required by the Commissioner of Public Works and Mines. The examinations must show to the satisfaction of the examiners that the candidate possesses a knowledge of ventilation, modes of working coal, of timbering, of gas, of safety-lamps, of the requirements of the Mines Regulation Act and Special Rules sufficient to enable him to work properly as a miner or shot-firer, before a certificate be granted.

In the case of applications for certificates of service, the examiners shall satisfy themselves of the *bona fides* of the applicants, and may require such proof of service as is necessary for carrying out the requirements of the law in this respect. The examiners shall not grant a certificate of service or competency to any person of known bad character, and a certificate may be cancelled or suspended by the Commissioner of Public Works and Mines upon representation to him by a Board of Examiners that the holder of such certificate is guilty of drunkenness or other misconduct, and a Board of Examiners shall, to enable it to report to the Commissioner of Public Works and Mines, make enquiry forthwith into the truth of any such charge brought to its notice.

The fee to be paid by each person receiving a certificate shall be 50 cents [2s. 1d.], to be paid to the Examining Board, and to be divided between the two examiners. The forms of certificate, registration, etc., shall be such as the Commissioner of Public Works and Mines may from time to time direct. The certificates, books and forms, will be provided for the Boards of Examiners, and an annual allowance of $20 [£4] will be paid to each board of examiners for postage and stationery, but all other expenses will be defrayed by each board.

The Commissioner of Mines may make such rules for the Boards of Examiners as may be found necessary for carrying on their work, and these rules may be at any time revoked or changed, or new ones made by the Commissioner of Public Works and Mines, who shall have power to do whatever is herein overlooked, or may hereafter be required, for the more efficient carrying out of the law.

The writer adds to his paper a copy of the portion of the Act (Appendix VII.) referring to underground officials, and a set of the forms of certificates issued to miners and shot-firers (Appendix VIII.).

APPENDIX I.—AN ACT RESPECTING SCHOOLS OF INSTRUCTION FOR MINERS, PASSED ON APRIL 17TH, 1889.

Be it enacted by the Governor, Council and Assembly as follows:—

1.—The Governor-in-Council may authorize the establishing of a school of instruction for miners at any place in the province at which coal-mining operations are carried on, for the purpose of instructing persons who may wish to prepare themselves to undergo examination before the Board of Examiners referred to in section 8 of chapter 7, revised statutes, and may appoint teachers for such schools, and may fix the time for which such teachers shall hold their appointments.

2.—The teachers of the schools established under the provisions of the first section shall prepare candidates in accordance with the rules now prescribed, or which hereafter may be prescribed, by the Board of Examiners, or with such rules as may be made by the Governor-in-Council.

3.—Each teacher preparing and sending up for examination not less than two properly qualified candidates shall be entitled to a fee or retainer of $100 [£20] per annum from the province. If it shall appear to the satisfaction of the Commissioner of Public Works and Mines that the failure of candidates to pass the examination was not due to any default of the teacher, such teacher shall be entitled to the said fee or retainer, notwithstanding the candidates' failure.

4.—Any teacher who has prepared candidates who have successfully passed the Board of Examiners shall be entitled to such fees for each candidate passed as an overman or underground manager as may be fixed by the Governor-in-Council, such fees to be paid by the Commissioner of Public Works and Mines on the certificate of the chairman of the Board of Examiners.

5.—No teacher shall be allowed to exact from any intending candidate any fee for the instruction given by him; provided, however, that this shall not apply to any person desiring instruction, but not contemplating examination.

6.—The standard of efficiency and system of marks and of examination shall be the same as that now in force, or that may hereafter be decided upon by the Board of Examiners.

7.—No fee shall be charged by the Board of Examiners to candidates who have been prepared at any school established under authority of this Act.

8.—The Governor-in-Council shall cause each teacher of the schools of instruction for miners to be supplied with a proper outfit of instruments, to be used for the purpose of instruction. Such instruments shall be held as the property of the province, and the teacher, whenever so requested, shall return them to the Commissioner of Public Works and Mines, and shall make good any damage beyond reasonable wear and tear.

9.—The rent of rooms or buildings, the cost of fuel and light, and other incidental expenses in connexion with the schools, shall be a provincial charge, and shall be paid by the Commissioner of Public Works and Mines.

10.—The Governor-in-Council shall have power to make from time to time such regulations as may be necessary or useful in making the said schools of instruction effective for their purpose.

11.—The schools of instruction for miners at present in operation, established by order of the Governor-in-Council, are hereby declared to be established under the provisions of this Act.

APPENDIX II.—Memorandum *re* Examinations for Engineers.

There are three classes of certificates:—First, second and third.

Qualification as to age.—A candidate for any grade must be at least 18 years of age, and, if required by an examiner, produce a certificate to that effect from his parents or guardian, or some reputable person.

A candidate for the third or lowest grade must have served as fireman or engineman, or both, for a period of at least 12 months.

For the second grade, the candidate must have served in connexion with engines and boilers for a term of not less than 2 years.

For the first grade, the candidate must be a holder of a second or third-class certificate, and have had at least 2 years' practice in making or repairing engines.

In all cases the certificates of employment must be satisfactory to the examiner.

In the case of any examination, should the candidate not secure enough marks to reach a higher grade, he can obtain a lower-grade certificate, provided that he has secured enough marks for to entitle him to such lower-grade certificate.

The examination will be conducted by means of written answers to written questions, and be supplemented by *viva-voce* examination, if deemed necessary. The questions for the three grades will be on one paper, and a specified number will be taken by the candidates for each grade, as deemed proper by the Board.

In any examination, the candidate must secure at least 50 per cent. of the number of marks allotted to the questions selected by him in order to receive a certificate.

The local examiner will, upon application, furnish a form as to age, employment, etc., to be filled up and returned to him at least 20 days before the date of the examination.

APPENDIX III.—Engineers' Examination.—Memorandum for Candidates.

Applicants for a third-class certificate will take the papers A and B.

Applicants for a second class and who do not already hold a third class will take the papers A, B, C, D and G, but if they have a third class, C, D and G will be sufficient to secure a second class.

Applicants for a first class who do not already hold a second class will take the papers C, D, E, F, G and H, but if they have a second class, E, F and H will be sufficient to secure a first class.

Applicants for the third and second class must secure at least 55 per cent. of the number of marks allotted for each question.

Applicants for the first class must secure 75 per cent.

Paper A.—Boiler Questions.—Third Class.

1. What would be your first duty on taking charge of boilers?
2. Which needs the most care and constant attention, the engine or the boiler?
3. Why so?
4. Into what two general classes may boilers be divided?
5. Describe an internally fired boiler?
6. How many gauge-cocks should be used, and how should they be placed?
7. How high should the water be carried?
8. Suppose that, owing to a break-down of the pump or of the injector, or any other cause, the water should get so low as to disappear in the glass gauge and lowest gauge-cock, and you had no means at hand with which to get more water into the boiler, what would you do. Would it be advisable to raise the safety-valve?

9. What would you do if your glass gauge were to burst?
10. Suppose you found your new glass 1 inch too long, how would you cut 1 inch off, quickly and neatly?
11. What would you do after you put the new glass in?
12. Would you trust your glass gauge entirely?
13. If the gauge-cocks should get stopped up, how would you clear them?
14. What is a safety-valve?
15. How many kinds or types of safety-valves are in general use?
16. Will not a lever safety-valve stick fast in its seat sometimes?
17. What is a check-valve, and what are its functions?
18. Do not check-valves sometimes get caught up so that they will not seat, and what is the result?
19. Will you name in what particular way boilers are generally neglected and abused?
20. What precaution should be taken in opening or closing any kind of valve, be it safety-valve, throttle-, stop-, or blow-valve?
21. When intending to blow out for repairs or scale, what would you do?

Paper B.—Engine Questions.—Third Class.

1. What do you consider the first qualification for one, who runs a steam-engine, to possess?
2. Should not an engineer be a machinist by trade?
3. How and where can one learn about machinery outside of the shops?
4. How often would you oil an engine?
5. Suppose you had a sight-feed on the cyclinder, and automatic cups on the journals, would you still go around oiling with your oiler?
6. Which is the proper way to key up, or screw down a journal?
7. What are an engineer's duties while on watch?
8. How are steam-engines rated?
9. What is a horsepower?
10. What do you understand by mean effective pressure?
11. How do you find the piston-speed of an engine?
12. What is friction?
13. Does friction increase with the extent of the rubbing-surfaces?
14. What is the object of cylinder-clearance?
15. What precaution should be used in reference to cylinder-clearance?
16. After keying or lining up the connecting-rod, what precautions would you use?
17. Explain the difference between condensing and non-condensing engines.

Paper C.—Boiler Questions.—Second Class.

22. How can an engineer set a safety-valve in a practical manner without the aid of mathematics?
23. Can smoke be burnt by any means?
24. What will cause a boiler to be a poor steam-maker, and be inefficient, wasteful of fuel, etc.?
25. Should land-boilers be inspected by some responsible boiler-inspector?
26. What is steam?
27. Why do you say that it is invisible? Can we not see it plainly as it issues from the exhaust-pipe of a non-condensing engine?
28. What is meant by wet steam?
29. Is not wet steam a source of danger?

30. What is the cause of wet steam?
31. How can you tell when the boiler is foaming badly?
32. What would you do in such an emergency?

Paper D.—Engine Questions.—Second Class.

18. What are the mechanical powers?
19. What is meant by mechanical power?
20. Explain in simple language the gain by expanding steam?
21. Suppose you had an engine in which a set-screw was used on the eccentric, and the eccentric not marked, and that eccentric should slip, and there was no time to go through the usual methods of setting valves, as hundreds of men were waiting; and the work had to be done at once: what would you do?
22. What is the horse-power of a 16 inches by 36 inches engine running 50 revolutions per minute with 45 pounds mean effective pressure?
23. What are the relative positions of the crank and the eccentric?
24. When the cut-off is independent and rides upon the back of the main valve, what is the relative position of its eccentric to the crank?
25. How is such a cut-off generally adjusted?
26. Should all the brasses of an engine be taken off and examined occasionally?

Paper E.—Boiler Questions.—First Class.

33. How would you find the area of a safety-valve for any given size of boiler?
34. What is the difference between a hard patch and a soft patch?
35. On what portions of the boiler would you place a hard patch?
36. What precaution must be taken in putting on a hard patch?
37. What is the first thing to do when a crack is noticed?
38. How are steam-boilers tested for strength?
39. Why is it that so few marine boilers explode?
40. Suppose a cap leaked while steam was up, would you attempt to tighten up the cap-nut?
41. When should the hydrostatic test be applied to boilers?
42. How should a safety-valve be constructed and attached to a boiler?
43. Which is the best way to run an escape-pipe from a safety-valve?
44. Give a simple rule for calculating the heating-surfaces of steam-boilers?
45. How can the horsepower of a boiler be estimated roughly?
46. How should steam-boilers be worked with a view to economy and safety?
47. What is the bursting and safe working-pressure of a boiler, 60 inches in diameter, 30 feet long, longitudinal seams, double-riveted, plates $\frac{3}{8}$ inch thick, best mild steel, tensile strength 50,000 lbs.?

Paper F.—Engine Questions.—First Class.

27. How would you set a slide-valve?
28. What horsepower would be required for a fan to produce 200,000 cubic feet of air per minute, the water-gauge reading 2 inches, if the useful effect be 60 per cent.?
29. Explain what is an indicator.
30. How would you proceed to apply an indicator?
31. Explain the indicator-diagram now before you, and compute the indicated horsepower of same.

Paper G.—Pump Questions.—Second Class.

1. Explain the term "suction" of a pump.
2. From what causes is an imperfect vacuum most likely to arise?
3. Suppose a vacuum-gauge showed 30 inches, would not that prove a perfect vacuum?
4. Can you pump hot water with a pump?
5. What causes pump-valves to pound sometimes?

Paper H.—Pump Questions.—First Class.

6. Give your reason why all duplex straight-line pumps should have four steam-ports.
7. What is the proper lift for any conical or circular valve, be it a check, safety, or other kind of valve?
8. What position should the air-pump occupy relatively to the condenser?
9. How much condensing water is required per horsepower of engine?
10. How many gallons of water will a cistern or dam 170 feet long by 10 feet high and 12 feet wide contain?
11. How long would it require to fill the above cistern or dam with a single double-acting plunger-pump, each plunger being 6 inches in diameter, having a stroke of 24 inches, and making 140 feet per minute?

APPENDIX IV.—MANAGERS' EXAMINATION.

Paper I.—Geology.—(Time, 1 hour.)

1. What advantage has a knowledge of geology for miners?
2. In a search for minerals, what help may a knowledge of fossils bring?
3. Describe and illustrate a fault.
4. What does the term "denudation" mean?
5. Sketch an overlap of strata.
6. Distinguish between stratified and igneous rocks.

Paper II.—Mechanics.—(Time, 2 hours.)

1. What is meant by the co-efficient of friction of an engine?
2. What thickness of plate would you give to a Lancashire boiler 6 feet in diameter by 30 feet long, carrying a pressure of 45 lbs. per square inch? The boiler to be double-riveted. Give reasons.
3. What is the nominal horsepower of a plain cylindrical boiler 30 feet long by 5 feet in diameter?
4. By sketch, show how you would fasten a round steel rope, 1½ inches in diameter, to a cage.
5. Find the horsepower of a hauling-engine for a plane 2,000 yards long, and with a rise of 4 inches to the yard for an output of 1,000 tons in 10 hours. Make allowance for friction.
6. What precautions would you take if, through a deficiency of water, a boiler became overheated?
7. What is the proper treatment to ensure a long life to wire-ropes?
8. What quantity of water would pass through a 6 inches pipe 5,000 feet long, with a head of 50 feet?

Paper III.—Ventilation.—(Time, 3 hours.)

1. A mine has two airways, one 5 feet by 8 feet and the other 5 feet by 6 feet, with equal volumes of air passing. The 5 feet by 8 feet airway is 1,000 feet long. How long will the other airway be?

2. If a water-gauge of 1·10 inches gives a current of 20,000 cubic feet of air per minute, what will be the water-gauge with 30,000 cubic feet per minute?
3. A water-gauge of 1 inch and 50,000 cubic feet of air are produced by a fan and steam-pipes in the upcast. The steam-pipes alone produce 10,000 cubic feet. What quantity will the fan give, if the steam-pipes are transferred to the downcast pit?
4. A fan at 50 revolutions produces 100,000 cubic feet of air with 2 inches of water-gauge, what will be the water-gauge, the number of revolutions, and the horsepower when the production increases to 120,000 cubic feet of air per minute?
5. A ventilating-current is passing at 5 feet per second. What increase of power will be required to double the velocity?
6. The temperature of a downcast is 40° Fahr., that of the upcast being 70° Fahr. What volume of air in the upcast will weigh the same as 1 cubic foot in the downcast?
7. The pillars about the shaft-bottom are to be 120 yards square from the shaft in all directions. Show by a large sketch, giving dimensions with description, how you would arrange the airways during the formation of the pillars. The coal gives off fire-damp freely.

Paper IV.—Modes of Working.—(Time, 3 hours.)

1. What instructions would you give to shot-firers in coal-mines?
2. Describe the safety-lamp that you like best, and name the make that you prefer for use at the working-face, on hauling-roads, and for official examinations.
3. Describe a method for securing a circular shaft with wood. Give the sizes of timbers for a shaft 10 feet in diameter.
4. Sketch and describe different methods of timbering a main-road in a flat seam.
5. Describe arrangements for getting coal from the working-faces to the main-roads underground in mines with considerable dip, and mention precautions to ensure the safety of the workmen.
6. Describe fully some system of underground-haulage, and mention the conditions in the mine that would govern your selection of that particular system.
7. On opening a seam of coal in a new field unaffected by old workings, what conditions would lead you to advise the selection of bord and pillar in preference to longwall?
8. Sketch, with measurements, the openings about a pit-bottom laid out for longwall.

Paper V.—Surveying.—(Time, 2½ hours.)

1. Lay down the following underground survey on the scale of 2 chains to 1 inch:—

Distance.		Chains.		Horizontal Angles.
Shaft to A.	... ...	1·90	...	A 145° 15′
A. B.	... ...	6·75	...	B 177° 30′
B. C.	... ...	4·30	...	C 213° 54′
C. D.	... ...	9·77	...	D 97° 20′
D. E.	... ...	3·90	...	E 130° 13′
E. F.	... ...	6·13	..	F 167° 30′
F. G.	... ...	3·01		

NOTE.—The horizontal angles are those on the left hand of a person travelling in the direction of the survey, and the magnetic bearing of the

line F. G. is 30° east of north. Also reduce the above readings to one meridian, and plot your proof. Explain how you would correct the above survey if made in a seam considerably inclined.

2. Work out the following series of levels and plot in the form of a section. Horizontal scale, 1 chain to an inch. Vertical scale, 20 feet to an inch. Datum line, 50 feet.

Distance. Chains.	Back Sight. Feet.	Fore Sight. Feet.	Distance. Chains.	Back Sight. Feet.	Fore Sight. Feet.
0·70	1·30	8·85	5·40	8·80	1·12
1·50	8·85	2·30	7·00	2·32	7·05
2·45	13·96	5·40	9·40	1·33	9·96
3·60	5·40	0·52	10·20	3·34	5·87
4·05	12·62	8·80	11·35	5·87	9·10

3. What are the special advantages and disadvantages in the use of the ordinary miners' compass as compared with the theodolite?
4. How may underground and surface-surveys be connected (1) when access is had through workings open to the surface, and (2) when by shaft only?
5. Describe a simple method of determining approximately the true meridian.

APPENDIX V.—Examination of Candidates not Holding a Certificate.

Paper I.—Mines Regulation Chapter.—(Time, 2½ hours.)

1. Upon whom are penalties imposed for non-compliance with the Act, and for what offences?
2. When is it necessary to work a mine with safety-lamps, and what examinations are then required?
3. Respecting single shafts, what does the Act say?
4. What restrictions are put on the working of coal under the sea?
5. What are the regulations respecting the fencing off of certain workings?
6. Who may not be employed about machinery, above or under ground? and give reasons.
7. State the law respecting explosives, and fully state the conditions in a mine that would govern the application of each section of the law.
8. What restrictions are placed on the operations of prospectors?

APPENDIX VI.—Underground Managers' and Overmen's Examination.

Note.—Papers 1 and 2 of managers' examination are not given to under-managers or overmen.

Paper III.—Ventilation.—(Time, 3 hours.)

1. What is an air-crossing? and give the size to pass 5,000 cubic feet of air per minute.
2. In an airway, 9 feet by 7 feet, the anemometer makes 425 revolutions per minute. What quantity of air is passing?
3. The temperature in a downcast is 40° Fahr., in the upcast 70° Fahr. What volume of air in the upcast will weigh the same as 1 cubic foot in the downcast?

4. The upcast and the downcast shafts are 500 yards apart. Twenty men are employed in a section of working situated 700 yards from the downcast and 450 yards from the upcast. The downcast takes fire. How would you propose to rescue the men? and how many men would you send in each rescue-party?
5. A ventilating-current is passing at 5 feet per second. What increase of power will be required to double the velocity?
6. In a mine giving off a good deal of gas 200 persons are employed, and the intake airway is 5,000 yards long. What size would you have the airway? and give your reasons.
7. The shaft-pillars are to be 120 yards square from the shaft in all directions. Show by large sketch, giving dimensions with description, how you would arrange the airways during the formation of the pillars. The coal gives off fire-damp freely.

Paper IV.—Modes of Working.—(Time, 3 hours.)

1. What instructions would you give to shot-firers in coal mines?
2. Describe the safety-lamp that you like best, and name the make that you prefer for use at the working-face, on hauling roads, and for official examinations.
3. Describe a method for securing a circular shaft with wood. Give the sizes of timbers for a shaft 10 feet in diameter.
4. Sketch and describe different methods of timbering a main road in a flat seam.
5. Describe arrangements for getting coal from the working-faces to the main-roads underground in mines with considerable dip, and mention precautions to ensure the safety of the workmen.
6. Describe fully some system of underground haulage, and mention the conditions in the mine that would govern your selection of that particular system.
7. On opening a seam of coal in a new field unaffected by old workings, what conditions would lead you to advise the selection of bord and pillar in preference to longwall?
8. Sketch, with measurements, the openings about a pit-bottom laid out for longwall.

Paper V.—Surveying.—(Time, 2½ hours.)

1. What is meant by the term true meridian? Describe a simple method for approximately determining it.
2. How may underground and surface-surveys be connected: (1) when access is had through workings open to the surface; and (2) when by shaft only?
3. Explain, by writing, how to level and plot a section.
4. What are the special advantages and disadvantages in the use of the ordinary miners' compass as compared with the theodolite?
5. Lay down the following survey on the scale of 2 chains to an inch:—

Distance.	Chains		Horizontal Angles.
Shaft to A.	1·90	A	145° 15′
A. B.	6·77	B	177° 30′
B. C.	4·30	C	213° 54′
C. D.	9·77	D	97° 20′
D. E.	3·90	E	130° 13′
E. F.	6·13	F	167° 30′
F. G.	3·01		

The horizontal angles are those on the left hand of a person travelling in the direction of the survey, and the magnetic bearing of the line F. G. is 30° east of north.

Paper VI.—Scholarship.—(Time, $2\frac{1}{2}$ hours.)

1. Multiply $2\frac{1}{3}$ by $4\frac{1}{8}$.
2. Divide 4·675 by 0·3.
3. Find $\sqrt{3{\cdot}001}$.
4. What are the area and circumference of a circle whose radius is 4 feet?
5. A., B. and C. work together in a place 6 feet by 9 feet, they dig 200 feet ahead and are paid 50 cents per cubic yard. A. works 20 days, B. works 22 days, and C. works 24 days. How much does each receive?
6. What is the weight of 1 cubic yard of ironstone that has a specific gravity of 4·75?
7. What is the equivalent horsepower of 2,965,000 units of work per minute?
8. What must be the diameter of a working-barrel to pump in 12 hours as much water as one 12 inches in diameter does in 20 hours? Both going at the same speed.

APPENDIX VII.—Extract from Mines Regulation Act, Nova Scotia, respecting Managers, Underground Managers and Overmen.

40.—Every coal-mine to which this chapter applies shall, after the first of January (1890), be under the control and supervision of a manager, and the owner or agent of every such mine shall nominate himself or some other person to be the manager of such mine, and shall send written notice to the Commissioner of the name and address of such manager. And in no mine to which this chapter applies shall any person not now employed as a miner be "given the picks" to work as a miner unless he has been employed in a mine, in some capacity, for the space of one year. No one shall be given charge of a working-face in a mine who has not worked previously in a mine for the space of two years, nor shall any one now a miner be employed after the first of January to mine coal who is not a holder of a certificate of service; and no one not now a miner shall be "given the picks" to work as a miner until granted a certificate of competency after examination by the Board of Examiners appointed for the purpose of granting certificates as managers, overmen or shot-firers, or by an examining board to be hereafter appointed, who shall have power to frame laws and conditions under which said certificates shall be granted.

41.—The underground workings of every coal-mine to which this chapter applies shall be under the daily charge of an underground manager and overman holding certificates under this chapter.

42. A person shall not be qualified to be a manager, underground manager or overman unless he be the holder of a certificate under this chapter.

43.—If any coal-mine to which this chapter applies is worked for more than fourteen days without there being such a manager, underground manager or overman as is required by this chapter, the owner and agent of such mine shall each be guilty of an offence against this chapter.

Provided that the owner and agent of such mine shall not be guilty of an offence against this chapter if he proves that he had taken all reasonable means by the enforcement of this section to prevent the mine being worked in contravention thereof.

If for any reasonable cause there is for the time being no manager of a mine qualified as required by this section, the owner or agent of such mine may appoint any person holding a certificate as underground manager under this chapter to be

manager for a period not exceeding two months, or such longer period as may elapse before such person has an opportunity of obtaining, by examination, a certificate as manager under this chapter, and shall send to the Commissioner a written notice of the name and address of such manager and the reason of his appointment.

44.—A mine in which less than thirty persons are generally employed underground shall be exempt from the provisions of this chapter so far as relates to the appointment of a manager, unless the inspector by notice in writing served on the owner, agent or manager requires the same to be under the control of a manager; but the operations underground shall be under the charge of persons holding certificates as underground managers or overmen under this chapter, unless permission be given by the Commissioner that the operations underground may be under the charge of one such person.

45. -All certificates for managers, underground managers and overmen shall be issued by the Commissioner upon the report of the Board of Examiners appointed under the provisions of the law of mines and minerals.

46.—The Board of Examiners shall draw up rules for the guidance of their proceedings, and shall conduct examinations for granting certificates of competency under this chapter, and may from time to time make, alter and revoke rules for the conduct of such examinations and for determining the qualifications of applicants; so, however, that in every such examination regard shall be had to such knowledge as is necessary for the practical working of coal-mines in this Province, and for the determination of the qualifications of applicants for certificates of service as underground managers and overmen, and shall from time to time report to the Commissioner the names of the persons qualified to receive certificates, and shall do such other things as are necessary for the proper discharge of their duties under this chapter; and the Governor-in-Council shall have power at any time to alter and revoke any rules made by the Board of Examiners.

47.-The fees and travelling expenses to be paid to the Board of Examiners and the fees to be paid by applicants for ertificates shall be determined by the Governor-in-Council.

48.—A register of the holders of certificates under this chapter shall be kept at the office of the Commissioner by such person and in such manner as he may from time to time direct.

49.--Persons holding certificates of competency granted by an English Secretary of State or other property constituted authority in Great Britain may, upon passing the regular examination provided for in this chapter, be granted a certificate as underground manager or overman, but previous to the first meeting of the said board of examiners the said certificate, upon first being approved of by the inspector of mines, shall be valid.

50.—A certificate of service shall have the same effect only in the mine for which it was granted for the purposes of this chapter as a certificate of competency granted under this chapter.

APPENDIX VIII.—CHAPTER 8.—REVISED STATUTES OF THE REGULATION OF MINES. PROVINCE OF NOVA SCOTIA. ....EXAMINING BOARD.

I.—*Certificate of Competency as Miner.*

............No......... 189

This is to certify that..having undergone the examination required by the provisions of said Act, is hereby granted a certificate of competency as miner; but this certificate does not entitle the holder to take charge of a "working-face."

.... } Examiners.
....

II.—*Certificate of Competency as Miner.*

............No......... 189

This is to certify that..having undergone the examination required by the provisions of said Act, is hereby granted a certificate of competency as miner, entitling the holder to take charge of a "working-face."

.... } Examiners.
....

III.—*Certificate of Competency as Shot-firer.*

............No......... 189

This is to certify that..having undergone the examination required by the provisions of said Act, is hereby granted a certificate of competency as shot-firer.

.... } Examiners.
....

A vote of thanks was passed to Dr. Gilpin for his paper.

The following paper by Mr. J. E. Breakell on "Treatment of Refractory Silver-ores by Chlorination and Lixiviation" was read:—

TREATMENT OF REFRACTORY SILVER-ORES BY CHLORINATION AND LIXIVIATION.

By J. E. BREAKELL.

Introduction.—It would be presumptuous for an individual having had experience in the treatment of only two or three refractory ores, to advise with perfect confidence on another, which, although falling under the same category, may require very considerable modification in the several departments of its treatment. At the same time, he who understands the process thoroughly will be able to prove by simple tests, whether the hyposulphite process would be suitable or not for any exceptional ore. But with regard to the plant that he might suggest, he would very probably make grave errors. The remarks contained in this paper are therefore meant to refer more especially to heavy sulphide ores, that is, containing from 40 up to 80 per cent. of sulphides.

Under certain conditions, the actual mining of the ore has important bearings on the final result of the metallurgical method. These conditions are :—(1) when the mine is not developed well in advance of the plant, and (2) when the ore is extracted from a number of lodes, which vary one from another in their contents of the different sulphide minerals. In either case, the evil is the same, there will be without extreme care in mining a continual tendency to change in the nature of the ore supplied to the mill.

The writer worked a mine, at which the ore was taken from four different lodes, and each one had its little peculiarity. For example :—Although all contained iron-pyrites, copper-pyrites, zinc-blende and galena, three of the lodes gave one of these ores in excess of another, while the fourth was treated with 90 per cent. of gangue, because of its richness in silver sulphide, ruby silver and galena, very finely divided. Great foresight was necessary to mine the ore from these different lodes, in such proportion and quality that each respective lode would yield the same quality for the longest period, and, of course, the quantity mined depended on the ore in sight in each case. Four qualities of ore were supplied to the mill, but as the proportion did not vary, the milled mineral charged to the furnaces was kept uniform in quality.

There are several reasons why the mineral should not be allowed to vary, which are as follows:—

(1) In order that the furnace-men shall understand their work with greater facility: for it must always be borne in mind that the roasting is the most difficult part of the process to accomplish to perfection, and if the nature of the ore changes every now and then, modifications in the furnace-work would be necessary and the result would be a sequence of costly experiments.

(2) As a rule, distinct sulphide-ores assay very differently, and it is not infrequent that a particular ore varies in value from the same lode. It is always advisable to keep the ore supplied to the furnaces of the same value as much as possible, and that value should depend on the state of development in comparison with the milling-power. For instance, if the tonnage in sight is far beyond the milling-capacity of the plant, then, of course, it is reasonable, if possible, to raise the value to a certain extent.

(3) If zinc-blende be present, it should not be allowed to predominate, as this sulphide is the least amenable to the roasting-process, and if copper be not present, then the blende sometimes ruins the result altogether. However, this point will be mentioned more explicitly under the head of roasting.

(4) Any mineral of copper in the ore gives very evident advantages over one which does not contain it, in helping the final extraction of the silver. But it also has a disadvantage when present in excess, and that is the loss by volatilization in roasting increases with the percentage of copper. It should be, therefore, always present if possible, but in moderation.

(5) If calcareous minerals are present in large quantities, and the ore is not very heavy in sulphides, then the sulphuric acid generated, in roasting the sulphides, is apt to be neutralized by the caustic lime which is formed, and the result would be that the solutions become alkaline, which is detrimental to high extraction.

It is obvious, in the face of these facts, that the mine-manager must understand the minerals which he is working, and be able to ascertain far in advance the future yielding capabilities of his different lodes, and work them so that the different minerals do not enter the furnaces indiscriminately.

Milling.—When an ore is to be roasted and leached, there are three momentous points to govern one in deciding which will be the best mode of milling:—(1) The furnaces must be charged dry; (2) the mineral

must be so fine as to chlorinate freely; and (3) last, but not least, is the important question of not crushing too fine, as a comparatively small proportion of slimes sometimes stops the leaching rate (*i.e.*, percolation) of wash-water and solutions to such a degree as to be impracticable.

To arrive at the required effects, grinding-machines suggest themselves as the most suitable; and of these rolls have the best name amongst machines for dry crushing, because of the fact that the material is quite uniformly ground.

The objections to stamp-batteries are:—(1) The slimy nature of the milled ore, and (2) the slowness of milling when dry, caused by the unnecessary length of time during which the ore hangs back in the mortar-boxes, and this is the case even with very coarse screens. For example, the following test shows the comparative value in chlorination of coarse and fine ore, on a sample taken from 20 tons crushed dry by stamps, and the mesh used on the mortar-boxes was No. 5 (or 25 meshes per square inch). The mineral was roasted with only 2 per cent. of salt, which is extremely low. The sample taken was quartered, and one part showed:—

	Ounces per Ton.
Assay value in silver	35·9
Assay value of residues, after application of 5 per cent. hyposulphite-solution	13·1
Showing an extraction of 63 per cent. or	22·8

The rest of the sample was sieved with No. 50 mesh (or 2,500 meshes per square inch), and 58 per cent. passed the sieve and 42 per cent. remained on, and these two were tested separately as follows:—

	The Fine Part of 58 per Cent. Ounces per Ton.		The Coarse Part of 42 per Cent. Ounces per Ton.
Assay value in silver	40·85	...	31·0
Assay value of residues after application of 5 per cent. hyposulphite-solution	11·75	...	15·0
Showing an extraction of	29·10	...	16·0
	or 71·2 per cent.		or 51·6 per cent.

The fine ore yielded 13·1 ounces more than the coarse ore, or nearly 20 per cent. more. In each case, the residues-assay represents the tailings after leaching with hyposulphite-solution of 5 per cent. strength, although the same result would be got with a 1½ or 2 per cent. solution in practice.

The preceding test shows that, on this particular ore at least, the mode of crushing made about 50 per cent. of slimes or dust, and that the finer half of the ore was richer than the other half, proving that the

mineral becomes to a certain extent concentrated in the mortar-boxes, although dry, while the heavier sulphides form the dust or slimes, and the mineral was quite unleachable. The coarse part of the above sample was such that 20 per cent. of the whole sample would not pass through a No. 18 meshes sieve. The writer found that ore ground uniformly in machines gave in tests much better averages, notwithstanding that the ore being comparatively free from slimes, it would naturally be supposed that the silver would not be so freely exposed to the action of chlorine gas. In reality, the reason why better chlorination can be got from uniformly-ground ore as against one like the abovementioned is because volatilization increases with fineness.

To crush dry necessitates the operation of drying the mineral first, and the most economical way of accomplishing this appears to be in a series of kilns of the limekiln type, to hold, say, 20 tons each. Great advantages might be secured by increasing the heat required for drying until the mineral begins to burn, when, if it be a heavy-sulphide ore, it will need no more fuel, as the sulphur burns itself away. An experiment showed that the ore was afterwards so friable that the milling capacity was increased very considerably, and 60 per cent. of the volatile sulphur was eliminated with a minimum loss of silver by volatilization. The sulphur being so reduced, the time necessary for roasting in the reverberatory furnaces was also reduced, thereby increasing their capacity. The mineral was charged into the kiln just as it came from the mine, and contained all sizes up to 6 inches.

If the mineral be very pure or contains galena, the heat being so great causes smelting in places, and the result is a matte which is difficult to discharge; and for this reason the kiln must be built with very special facilities for discharging.

The calcining operation may be also done in stacks in the open air.

Chloridizing-roasting.—The writer's remarks will be limited to roasting in ordinary reverberatory furnaces, which, after all, are the most popular, and he believes it can be said of them "that this form is the only one that can be made to suit any class of refractory ore;" although, of course, shaft-furnaces and cylinder-furnaces will be much more economical on exceptional ores (Figs. 1, 2 and 3, Plates XIII. and XIV.).

Reverberatory furnaces are generally constructed with three floors called the top, middle and bottom-hearths. The top and middle-hearths

have a gradient of 1 in 15 to facilitate the lowering of the charges from one to another; the ends of these two floors form a step of not less than 4 inches fall, which serves as a division between the charges. The working-doors should not be more than 8 feet apart, and, for many reasons of convenience and economy, must be placed only on one side of the furnace.

The fire-box placed at the lower end of the bottom-floor must not be more than 2 feet wide, no matter what fuel is used; and the fire-bridge which divides the fire-box from the bottom-hearth is about 15 inches wide, and rises up to within 2 inches of the spring of the arch. The arches are divided from one another respectively, with the floors and fire-box, by 1 inch of space, so that the arch over one floor may be repaired without interfering with the adjacent one, and the intervening space is filled-in with clay. The side-walls are made 15 inches thick, and are stayed with clamps made of old-fashioned bridge-rails (weighing about 65 pounds per yard) or any other suitable material. These clamps are 4½ feet long, and have a hole punched 4 inches from either end to receive 1 inch bolts. One of the bolts passes over the arches and the other below the floor, and it is necessary to put these bolts and clamps about 4 feet apart at least.

The arch over each floor is provided with a charge-hole about 6 inches square, those above the two upper floors are for charging ore, while the one above the bottom-floor is for charging salt, and the centre of the bottom-floor itself is provided with a discharge-hole leading into the chlorination-chamber, which should be placed on the level of the cooling-floor, away from the working-side of the furnace.

The dimensions of a furnace being given, its capacity depends almost entirely on the percentage of volatile substances and the fineness of the ore. For example, a furnace of the above description with hearths 16 feet by 8 feet, would take charges of 2,000 lbs. of an ore containing 60 per cent. of sulphides giving off from 18 to 21 per cent. of volatile substances. It was found that this class of ore needed 15 to 18 hours' total time in furnaces, being 6 hours on the top hearth, 6 hours on the middle hearth, and the rest of the time on the bottom-hearth; and within every 6 hours a charge was drawn, being 4 in 24 hours. But with ores containing less than 10 per cent. of volatile substances, such as naturally decomposed surface-ores, very ganguey or previously calcined pyrites, the maximum time needed was 12 hours, or 4 hours on each hearth and six charges could be drawn in the 24 hours. The depth of the mineral on the floors would be in the first case 4 inches, and in the second 5 inches, owing to the difference in the specific gravity.

In roasting for chlorination of silver, the process differs from the oxidizing or dead roast practiced in the gold-chlorination process, inasmuch as in the former the oxidation is carried just far enough to decompose the sulphides to form sulphates and sulphuric acid, which are necessary components, while in the latter the sulphates are finally oxidized completely and the sulphuric acid is driven off.

To make a good chlorination, it is necessary to decompose nearly all the sulphides, and as one mineral needs more or less time and temperature than another, it becomes evident that the sulphide which needs the minimum time and heat (pyrites) is over-roasted by the time that the others are thoroughly roasted, hence the apparently complete oxidized state of the mineral.

Presuming that the silver is in the state of a sulphide, when contained in other sulphides, it is chemically combined with sulphur and it is impossible to eliminate that sulphur without loss of silver. In light ores, containing say not more than 15 per cent. of sulphides, the loss ought not to be of any great importance, but with heavy ores, it is the most serious drawback to the process, and the most difficult to avoid.

The writer has already mentioned some of the causes of loss by volatilization, and will now repeat them in the order of their significance: —(1) Inequality of fineness in crushing; (2) too high and sudden temperature; (3) zinc-blende in excess; (4) copper-ores in excess; (5) too much stirring, especially after the addition of salt; and (6) too much salt.

The following is an assay-office roasting test of a sample of mineral which contained about 25 per cent. of iron-pyrites, 20 per cent. of zinc-blende, and 50 per cent of gangue. It was crushed wet by stamps, passed through a No. 5 meshes sieve, dried, and repulverized by stamps through a No. 8 meshes sieve. The fineness was such that 50 per cent. was passed through a No. 50 meshes sieve and the rest remained on the sieve.

Samples.	Assay Value per Ton.	Time Roasting.	Loss in Weight.	Value after Roasting per Ton.	Theoretical Value per Ton.	Loss by Volatilization per Ton.	Loss by Volatilization
	Ounces.	Minutes.	Per Cent.	Ounces.	Ounces.	Ounces.	Per Cent.
(1) Average sample ...	34·60	45	14	32·65	40·20	7·55	21·8
(2) 50 per cent. passed the sieve ...	39·20	20	20	45·70	49·00	3·30	8·4
(3) 50 per cent. remained on the sieve ...	30·70	40	8	32·00	33·30	1·30	4·2

Each sample was roasted at exactly the same cherry-red temperature. The experiment shows that the loss by volatilization was more than three times as high as it would have been if the length of time in roasting could have been regulated to suit both the fine and coarse particles at one and the same time. In No. 1, the average sample, the fine part must have been ready for the salt in half the time that the coarse part was, and volatilization must have been going on during the extra time taken by the coarse particles. The loss was enhanced by blende, which, being of a lower specific gravity than pyrites, does not concentrate in the mortar-boxes of the mill to the same extent, and is discharged coarser; and under any circumstances zinc-blende is one of the most difficult sulphides to decompose.

The following test was made on samples taken from a charge during roasting in a reverberatory furnace, they are therefore only approximately correct, but serve to show where the loss was greatest when the furnace was not at a proper temperature. An average sample of the charge at the start contained 17 per cent. of volatile substances, and had an assay-value of 35·4 ounces per ton :—

Where Sample was taken.	Time after.	Loss in Weight.	Theoretical Value per Ton.	Assayed Value per Ton.	Loss per Ton.	Total Loss.
	Hours.	Per Cent.	Ounces.	Ounces.	Ounces.	Per Cent.
Top hearth	6	1	35·70	35·70	nil.	—
Middle hearth	6	13	41·00	39·85	1·15	3·2
Bottom-hearth ...	3	17	42·60	34·60	8·00	22·6
2½ per cent. salt added	¾	then drawn.	41·40	32·65	8·75	24·7

While it was on the top hearth the mineral was not burning, the furnace being too cold; but the temperature was raised when the charge was lowered to the middle hearth; it was raised still more when the charge was brought down to the bottom-hearth, and it was during the last 3 or 4 hours that the greater part of the loss ensued.

The following test illustrates the effect of copper in volatilization, and was only made on a small scale in a muffle. The sample was quartered and carefully divided into two, one part was roasted with 2 per cent. of salt in the ordinary way, and the other portion was previously mixed with 2 per cent. of copper-carbonate ore containing 11 per cent. of copper. The average raw sample had a value of 32·65 ounces per ton :—

Samples.	Value after Roasting per Ton.	Theoretical Value per Ton.	Loss by Volatilization per Ton.	Loss.
	Ounces.	Ounces.	Ounces.	Per Cent.
No. 1.—Containing no copper, gave off 10 per cent. in volatile substances	35·75	36·25	0·50	1·5
No. 2.—Mixed with copper-ore, gave off 10 per cent. in volatile substances	32·65	36·25	3·60	11·2

The preceding test shows an increase of loss by volatilization of 9·7 per cent. through adding the small proportion of copper-ore. This loss is quite unavoidable to a certain extent, but by constant experimenting may be brought down much lower in practice.

No rule can be given, generally speaking, for the roasting of ores, but it becomes necessary to make exact rules by experimenting on each individual case.

The first thing to find out is the shortest time needed, with the lowest temperature, and that time should be divided up into distinct periods for the charge to stay on each hearth, but the charge should not arrive down at the bottom-hearth without 75 per cent. of its volatile substances being eliminated. It should therefore start burning as soon as possible after charging, and should give off at least 20 per cent. on the top hearth.

In the case already mentioned, where the time on the top hearth was practically lost, the mineral arrived into the greater heat of the middle hearth while it still contained all its sulphur, in consequence of which the heat became excessive and very sudden.

The quantity of salt to be used and the time to add it must be proved by extraction-tests: as a rule, from 3 to 8 per cent. is used. The exact point to add the salt is somewhat difficult to judge, but there is a certain stage which is easily recognized by the furnace-men, and it is arrived at when the ore becomes apparently moist and spongy, so that it will stand after having been pushed with the rake. On raking the charge previous to this stage, the ore runs from the hoe with great swiftness, owing to the fact that it is in a state of suspension, being impregnated with partially free sulphur. When the ore has attained the spongy stage, it is in reality too free from sulphur, and it becomes essential to add either a proportion of pyrites or sulphur, with the salt, to ensure the decomposition of the salt and the liberation of the chlorine gas. Otherwise a portion of the salt would be lost by remaining in its original state,

and it in turn would cause loss of silver in the first wash-water, by dissolving it, if the base metals are not precipitated (and, generally speaking, they are not worth the chemicals). The time of exposure with the salt may be from ½ to 1 hour according to experiment, and a few minutes make a great difference for good or bad in individual cases. When the salt is added, the charge should be thoroughly stirred to mix it evenly, and it is then heaped up in the middle of the hearth, and left for ½ hour or so, the operation of stirring, etc., is repeated at half-time, and after the charge has undergone the required time indicated by tests as giving the highest result, it is discharged through an opening in the middle of the floor, and its receptacle is the chlorination-chamber already referred to, where it remains as long as is convenient, because chlorination goes on so long as the ore keeps red-hot, which will be for two days if not drawn out. But to leave the mineral so long is not often practicable, as the chamber would need to be very large, to be able to contain all the mineral that is roasted in the time.

From the chamber the ore is raked out on to a cooling-floor, and when cool is damped down. Great care should be taken that the charge is as nearly cool as possible.

The writer previously remarked that zinc-blende ruins the result, at times, and it is in this operation that it happens. It has been found when zinc-blende is present in an ore to a large extent that there is always a portion of the same which remains as sulphide after the charge is drawn. And if wetted while hot the zinc sulphide becomes chloridized and otherwise decomposed, and very materially detracts from the chlorination of the silver which is reconverted into sulphide and native silver. These two are very much less soluble in sodium-hyposulphite solutions than silver chloride ; and if copper be not present, or be not introduced the final extraction will be lessened from 4 to 20 per cent. Copper plays the part of an auxiliary solvent in hypo-solutions, and when present in the charge in whatever form it may be, it is discharged as both sulphate and chloride. The sulphate is washed out in the first wash-water, the chloride is not so easily soluble in water but is soluble in the hypo-solution which takes it up, and it becomes sulphate through the action of the sulphuric acid contained in the hypo-solution. Copper sulphate in conjunction with hyposulphite, forms an energetic solvent for metallic silver and sulphide, it also increases the extraction of gold if present in the ore, and quite overcomes the evil effects of damping-down while hot; but at the same time it is always better to allow the charge to cool if possible.

The mineral is damped so as to be of such a consistency that it will make a ball when squeezed in the hand, but so that it falls to pieces with fingering. In this state the ore is charged into vats, where it is leached.

Leaching.—Leaching-operations may be carried on in the following routine: the times mentioned are only approximate, as they will differ with the fineness of the mineral, etc. :—

	Hours.
Vat-charging	4
First wash-water	24
Weak solution	6
Strong solution	60 to 72
Weak solution	5
Second wash-water	6
Discharging	4

The capacity of the leaching-plant should be rather greater than that of the furnaces, so that if any vat-charge needs more time than usual it may have more without interfering with others and causing delay.

The arrangement of vats may consist of four series, placed preferably in rows one behind another, and the level of the bottom of each row must be at least 6 inches higher than the top of the staves of those below (Figs. 1, 2 and 3, Plates XIII. and XIV.)

To treat, say, 350 to 400 tons a month the vats necessary, as a rule, would be :—

First row	3 storage-vats, 10 feet in diameter, for water and solution.
Second row	5 leaching-vats, 14 feet in diameter.
Third row	6 precipitation-vats, 9 feet in diameter.
Fourth row	2 sumps, 8 feet in diameter. 1 storage-vat, 8 feet in diameter, for precipitates.

With the exception of the precipitation-vats they are all made about 4 feet deep, but the precipitation-vats should be made 7 feet deep.

First Row.—Each storage-vat on the first row is provided with an indicator-float to measure to $\frac{1}{4}$ ton. This is a simple apparatus made of a long strip of wood graded with tons, half-tons, and quarter-tons up to 10 tons (2,000 pounds), or the capacity of the vat, and is nailed vertically on the front of the vat. A weight suspended by a cord over a pulley and connected to the float serves as the indicator. Of course, in grading the strip of wood the number of inches representing 1 ton must be calculated finely, so that in bringing up the strength of

the solution the exact quantity of sodium hyposulphite may be added to make a given strength without loss of time. The indicator also serves to regulate the quantity of water or solution with which the mineral is treated.

Second Row.—On the second row are the filter or leaching-vats. The filter takes up some 4 or 5 inches of the height of the staves, and consists of scantling, say, 3 inches by 4 inches, placed parallel with each other, 1 foot apart on the bottom of the vat. On the lower side of the scantling, openings are cut near either end to allow the liquids to pass freely under them. The space between the scantling is filled in level with gravel, a filter-cloth is then put on, and over this again any sort of suitable matting, which will guard the filter-cloth from being cut with shovels. Each filter-vat is fitted with two hoses, one connected with the filter from the outside to allow the liquids to pass from the vat, and when not in use it must be hung up higher than the level of the liquids in the vats. It will be obvious from this that valves are not necessary, in fact they are objectionable. The other hose also extends downwards beneath the filter, but is fastened to the inside of one of the staves and projects about 6 inches above the same, where it may be connected or disconnected at will with another hose leading from the water storage-vat. The object of this hose is to effect upward percolation.

The leaching-vats are charged by means of trucks, tram-lines for which pass directly over them from the cooling-floor. For vats, 14 feet in diameter, it will be advisable to arrange two sets of rails, so that the dumping of the mineral into the vats is performed over a more extended surface, otherwise if much mineral be tipped in one place for the purpose of spreading afterwards, the mineral in that particular place would become tightly packed, so to speak, and would not leach so freely as other parts of the charge, and the consequence would be increase in value of the tailings.

Third Row.—The precipitation-vats are six in number, three being used for strong solution, two for weak solution, and one for wash-water or waste solution.

A level launder, constructed with three divisions, is placed over these vats from one end to the other ; each division may be 5 inches deep and 3 inches wide, and is made of 3 inches scantling and 2 inches boards, having a ½ inch bolt at intervals of 2 feet. Each division is used for one

of the three liquids—strong solution, weak solution, or wash-water. Over each precipitation-vat is a plug-hole in its own respective division of the launder.

The vats are provided with two outlets, one for liquids and the other for precipitates. The former is a hose connected to the vat about 18 inches above the floor of the vat, so that there will be no fear of the precipitates passing out after stirring the solution. This outlet consists of a hose of such length that on the outside of the vat it may be raised above the level of the solution in the vat, as in the case of the leaching-vats and storage-vats, to avoid the use of valves. On the inside, the hose has a float attached to the end in such a form that the opening of the hose hangs about 2 inches beneath the surface of the solution, and in this way the surface of the solution can always run direct to the sump.

Fourth Row.—The two sumps and one precipitate storage-vat are placed on the same level, together with an acid pump, filters for precipitates, and drying and roasting-furnace.

In charging the mineral into the leaching-vats, the vat is filled considerably higher than the staves, because the charge shrinks to such an extent that space would be wasted otherwise. The exact height must be found by experience in all cases of different kinds of ore, and should then be regulated, so that after the shrinkage there is 6 inches for the solutions above the charge.

In applying the solutions there are two points of importance to be observed, (1) the volume of the charge, and (2) the rate of percolation.

(1) The volume is the quantity of liquid contained in the charge after shrinkage, when there is no solution or water above the ore. This is best determined at the outset by connecting the water storage-vat hose to the upward filtration-hose of the leaching-vat, and allowing the water to pass up through the mineral until nearly covered, when the quantity which has entered may be read off on the indicator of the storage-vat. The volume varies very much under different conditions, but generally it is between 20 and 30 per cent. of the weight of the ore in the vat.

In this manner, the first wash-water is always applied at first, and when the mineral is covered over completely upward filtration is stopped and the outlet-hose is let down and dipped into the wash-water division of the launder. Fresh water is run in from the surface and allowed to run until no precipitate is shown on adding a few drops of sodium sulphide to a sample in a test-tube.

(2) The rate of percolation is the number of inches which the liquids sink through the mineral in 1 hour, and this must be measured and noted every now and then. If the rate be as low as ½ inch an hour, the ore may be improved by grinding coarser or by adding a greater percentage of salt. If the rate be excessive, say, more than 2½ inches an hour, the result may be improved by grinding the ore finer.

If big percentages of salt are used in roasting, the first wash-water may carry enough silver to be worth precipitating, because a portion of salt is always left undecomposed in the charge, and of course would form a somewhat concentrated brine-solution, which dissolves silver chloride. But when upward filtration is practiced, this extraction in the water is prevented; by turning the fresh water on the charge the brine-solution is diluted and the silver is precipitated as chloride again in the mineral. However, even under these circumstances, the water always carries a small quantity of silver, from 2 to 4 per cent. of the assay-value of the ore. The wash-water is run to waste, if it does not carry a reasonable quantity of silver.

When the charge is leached free from soluble base-metal salts—which, as already mentioned, is indicated by testing the liquid with a few drops of sodium sulphide in a test-tube until no precipitate is shown—the mineral is run nearly dry, and it is most important that pools of the solutions, etc., should always remain on the top of the ore, as otherwise it might be run so dry that shrinkage would go on to more than what may be called a normal extent, the rate of percolation would be lessened, the mineral would crack and fall away from the sides of the vat, and filtration would become uneven.

At this stage, about one-third to half a volume of weak solution is run on to the ore, its strength may be 0·5 to 0·8 per cent concentration in sodium hyphosulphite, and when this has sunk into the charge the strong solution is put on, the strength of which varies from 1·5 to 2·5 per cent. The weak solution displaces the water contained in the charge, the strong solution displaces the weak solution, and by this means the mechanical loss in sodium hyposulphite is minimized. When about one volume of solution has run into the charge, hyposulphite will have started to run from the outlet-hose and of course will be carrying silver, and this is easily detected in the same way as the base metals, by testing the solution with sodium sulphide.*

* Sodium sulphide is made in the mill by dissolving 3 parts of caustic soda in water, to which 2 parts of sulphur are added. It is done in a cast-iron boiler, say of 50 gallons capacity. The caustic soda is first dissolved in the smallest possible quantity of water, after which the sulphur is added little by little.

The solution will be extremely weak for the first hour or so, and is therefore run into the wash-water precipitation-vat, and after precipitation is run to waste. The solution as it runs from the ore-vats must be tested from time to time for sodium hyposulphite, by one of the volumetric tests, and when the solution becomes sufficiently strong the hose is changed to the weak-solution launder and after precipitation is pumped back to its respective storage-vat. When the solution has assumed nearly its full strength, the hose is changed again, to the launder leading to the strong-solution precipitation-vats, and from these it is run to its sump and pumped to the strong-solution storage-vat.

Test Solutions.—The following formulæ, the writer believes, are the most commonly used for volumetric tests of sodium hyposulphite :—

(1) Dissolve 5·121 grammes of chemically pure iodine in a litre-flask in 100 cubic centimetres of distilled water and add at once 7·5 grammes of potassium iodide. Bring the two chemicals together in the flask and leave them standing for 24 hours in a dark and moderately warm place, and if the iodine be not all dissolved, add a small quantity of potassium iodide, repeating the operation of bringing the two together, etc., until all is dissolved. Then fill up the litre-flask to the mark, shake well, and keep the test-solution in a dark-coloured stoppered bottle, away from the light.

(2) To 1 part of wheaten starch, previously damped, add 100 parts of boiling water. This 1 per cent. solution must be allowed to stand for some hours so as to settle, and the clearer surface-solution is decanted off and put into stoppered bottles : a very small quantity of salicylic acid is then put in, and the bottle is shaken until it is dissolved.

(3) To standarize these solutions make a small quantity of a 1 per cent. solution of chemically pure sodium hyposulphite. Of this take 10 cubic centimetres, add 1 cubic centimetre of the starch-solution, and make up the volume to 50 cubic centimetres with distilled water. Then run, from a glass-cocked burette, a quantity of the iodine-solution until the solution is coloured blue throughout, when if the iodine-solution is correct 10 cubic centimetres will have been used. If more was used, it will be advisable to correct the solution by dissolving more iodine, or if less was used, by adding water.

In testing solutions in the mill 10 cubic centimetres of the sample to be tested are taken, and for each cubic centimetre of iodine used the solution contains 0·1 per cent. of sodium hyposulphite. The solution may not be alkaline nor very acid.

The quantity of sodium hyposulphite used per ton varies from 4 to 7

pounds. This depends on not having a too large stock-solution, and also on the care with which the solutions are changed after displacement of the first wash-water, and at the finish the displacement of the solutions by the last wash-water. The mechanical loss is always much greater than the loss by decomposition, because in precipitation with sodium sulphide the sodium hyposulphite is regenerated almost completely, and that which is lost by decomposition through atmospheric influences is inappreciable.

The consumption of caustic soda per ton is 3 pounds, and of sulphur 2 pounds.

The strong solution is run into the ore from 60 to 72 hours: the exact time necessary is found by assaying the mineral and solutions at different stages. If a charge is percolating evenly, the extraction of silver is very sudden, and the following set of assays of solution go to show more or less the value of the solution at different times:—

	Hours.		Silver per Ton. Ounces.	Dwts.
During first	12	sodium hyposulphite-solution assayed	6	0
,, second	12	,, ,, ,,	24	0
,, third	12	,, ,, ,,	5	0
,, fourth	12	,, ,, ,,	0	17
,, last	24	,, ,, ,,	0	6

Half a volume of weak solution follows the strong solution, and this is displaced by the last wash-water when the mineral is discharged.

In precipitating, very dilute sodium sulphide is used; the solutions are stirred vigorously while pouring in, and then left to stand for a period of ½ or ¾ hour to settle, and the clear surface solution is decanted as already mentioned and returned to the storage-vats for further use.

Every week or so, the precipitates are run into the storage-vat on the fourth row; thence they are put into ordinary cloth-filters, and when in the form of a stiff mud they are dried very slowly in ovens, and then roasted. The value of the precipitates is very various, and they may contain from 20 to 50 per cent. of silver. The chief cause of these differences is the effect of strong and weak solutions; for instance, if a very strong stock solution be used the precipitates will be poorer, but, on the other hand, the extraction of silver will be greater. Stronger solutions extract certain base metals which are not soluble in weaker solutions.

The CHAIRMAN (Mr. George Lewis) proposed a vote of thanks to Mr. J. E. Breakell for his paper, and it was cordially approved.

Major-General Schaw's paper on "The Use of High-pressure Steam as a Possible Substitute for Gunpowder or other Dangerous Explosives in Coal-mining" was read as follows:—

REFERENCES.

[...]BER.

[...]HEWING DIVISIONS IN FLOOR.

[...]DITTO DITTO IN ARCHES.

[...]LOORS.

[...]ROM MILL.

[...]ON-CHAMBER.

[...]SSIBLE TO FURNACE-BOLTS.

[...]OOR.

[...]D VATS & *Ka* EXTENSION TO DUMP.

[...]LPHIDE BOILERS.

[...]ATS.

N FILTER-VATS.

O PRECIPITATION-VAT FOR WATER.

P DITTO DITTO WEAK SOLUTION.

Q DITTO DITTO STRONG SOLUTION.

R PRECIPITATE STORAGE-VAT.

S SUMP.

T FILTER.

U REVERBERATORY-FURNACE.

V PUMP.

W FRESH WATER SUPPLY-PIPES.

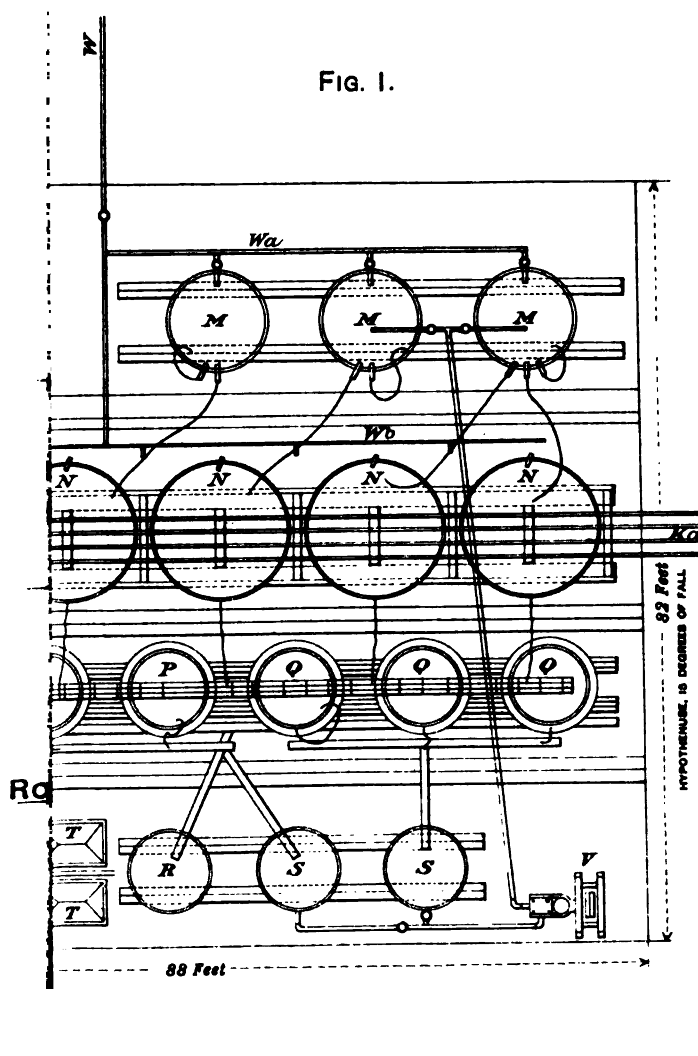
X ASSAY-OFFICE.

Y SAMPLING & STORAGE ROOM, SULPHIDES.

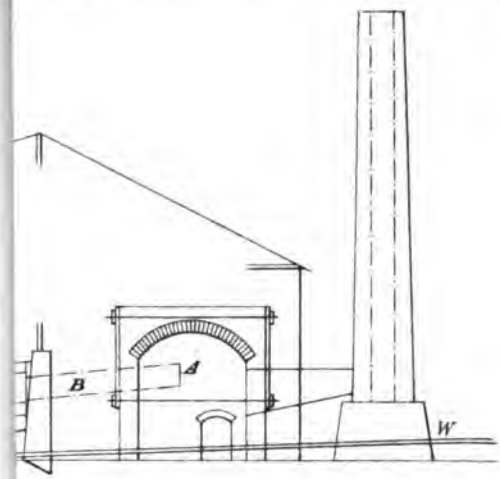
Z STORAGE-ROOM, CHEMICALS, &c.

G

FIG. I.



ores by Chlorination and Lixiviation."



IXIVIATION PLANT.

E SECTION

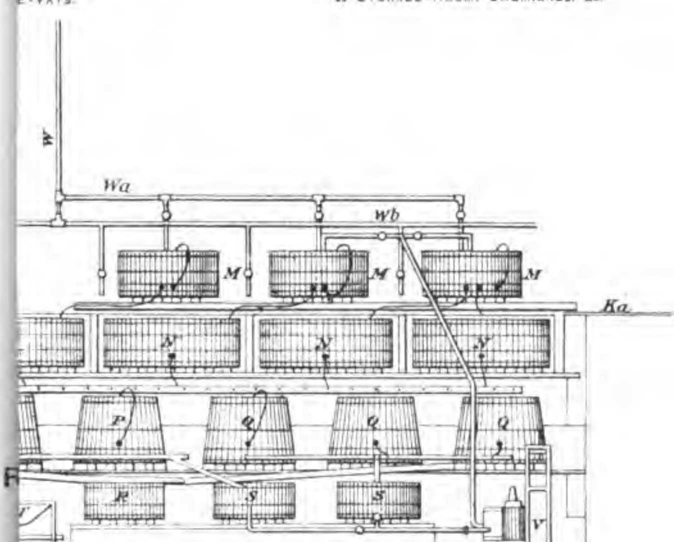
REFERENCES.

HAMBER

SHEWING DIVISIONS IN FLOOR.
DITTO DITTO IN ARCHES.
G-FLOORS

Y FROM MILL.
NATION-CHAMBER.
ACCESSIBLE TO FURNACE-BOLTS.
G-FLOOR.
Y TO VATS & *Ka* EXTENSION TO DUMP.
-SULPHIDE BOILERS.
E-VATS.

N FILTER-VATS.
O PRECIPITATION-VAT FOR WATER.
P DITTO DITTO WEAK SOLUTION.
Q DITTO DITTO STRONG SOLUTION.
R PRECIPITATE STORAGE-VAT.
S SUMP.
T FILTER.
U REVERBERATORY-FURNACE.
V PUMP.
W FRESH WATER SUPPLY-PIPES.
X ASSAY-OFFICE.
Y SAMPLING & STORAGE ROOM, SULPHIDES.
Z STORAGE-ROOM, CHEMICALS, &c.



THE USE OF HIGH-PRESSURE STEAM AS A POSSIBLE SUBSTITUTE FOR GUNPOWDER OR OTHER DANGEROUS EXPLOSIVES IN COAL-MINING.

BY H. SCHAW, C.B., MAJOR-GENERAL ROYAL ENGINEERS (RETIRED).

A disastrous explosion in a coal-mine at Brunnerton, in New Zealand, last year, which was attended with great loss of life, and which was caused by a shot-hole loaded with gunpowder having blown out its tamping, and thus, acting like a gun, igniting the coal-dust in its vicinity, led the writer to think whether high-pressure steam might be used instead of dangerous explosives in fiery coal-mines.*

Broadly, the suggestion is that a cartridge of pure water lodged in a shot-hole should be converted into steam at about 150 pounds per square inch pressure by means of electricity of low tension; the cartridge or boiler to be made of such strength that it would burst at about this pressure, when the force set at liberty would break down the coal.

The main question is: would this force be sufficient? It is of course very much inferior to the expansive force of gunpowder or other explosives. If, in the judgment of experienced mining engineers, the expansive force of steam would not be great enough to be practically useful in breaking down coal in ordinary coal-mines, which seems to the writer quite probable, then it is useless to pursue the subject further. Upon the supposition, however, that the force so developed would be sufficient to break down the undercut coal in a mine, the writer thinks that the practical working of the method would present no great difficulties, and that it would be perfectly safe in any coal-mine; and this is its only recommendation, for it would be certainly more expensive and troublesome than the usual methods of blasting.

As an approximation, the writer would observe that a water-cartridge $1\frac{3}{4}$ inches in diameter and $3\frac{1}{2}$ inches long, to be used in a 2 inches blast-hole, would hold about 8·4 cubic inches of water. It would be converted into high-pressure steam, and burst the cartridge in about 1 minute with the electrical power which the writer suggests, and would thus exert a sudden force of about $1\frac{1}{3}$ tons.

* *Trans. Inst. M.E.*, vol. xiv., page 617.

If two cartridges were to be burst, either the time must be doubled or the electric current must be doubled, and an absolutely simultaneous explosion could not, the writer thinks, be ensured.

The source of electricity suited to the case would be a dynamo, so wound that at 800 revolutions per minute it gives a current of 160 ampères, with an electro-motive force of 60 volts, the internal resistance being 0·375 ohm. About 25 horsepower would be required to work this dynamo. The conducting cable must be of low resistance, about 0·625 ohm total resistance of cable.

With low-tension electricity such as the above, there is no danger of sparks, unless the conducting wires come into contact.

The heat required to boil the water in the cartridge is developed in a thin platinum wire, 6·1 inches long, 0·0127 inch in diameter, and weighing 28·18 grains per yard, and having a resistance of 1 ohm.

The current employed will fuse this wire at the instant that the cartridge bursts by the steam-pressure, and the heat is no longer conducted away from it by the surrounding water; the current is thus broken, and ceases. For additional security, it would be easy to devise an electro-magnetic circuit-breaker, to be included in the circuit near the dynamo, which would disconnect the cable instantaneously and warn the engine-driver to stop the engine as soon as the cartridge burst and the current was no longer needed.

The calculations which the writer has made on the subject, and a sketch of a form of cartridge which embodies the principles of the suggestion, but which probably could be improved upon, are given as an appendix.

This suggestion is made in the hope that if mining engineers deem it worthy, they will try it experimentally, and that, if it should prove successful, it may tend to a considerable saving of life.

APPENDIX.

The writer made an experiment to ascertain whether it would be possible to boil water by the heat produced by a current of electricity passing through a platinum wire, similar to that used for firing mines, immersed in water, and found that it was successful. He also found that it was desirable to use a single wire of suitable thickness and length, forming a single loop in the boiler or water-cartridge to be burst by high-pressure steam in the shot-hole. It was found objectionable to coil the wire so as to insert a greater length within the boiler, because (1) electricity passed between the coils of wire, and (2) the coils interfered with the free circulation of the water as it was being heated.

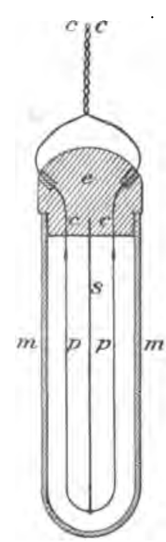
The writer was unable to obtain in New Zealand the necessary means for practically making experiments with a suitable boiler or cartridge; and, consequently, he is not aware whether water converted into steam, under pressure, will conduct the heat developed in the wire so rapidly away from it, as to prevent it from fusing, in the same way as the water does, before it is converted into steam. The writer is of opinion that it will do so, and that, at the moment when the boiler bursts, the wire will fuse, the electric circuit will be broken, and no risk of the ignition of fire-damp or coal-dust will remain from the heated wire. Should it be found that the wire fuses as soon as the water has obtained the full amount of latent heat necessry to convert it into steam, then it would be impossible to obtain high-pressure steam by this means, and the power developed might, perhaps, be insufficient for the purpose.

Calculations.—To convert water at 10° Cent. into water at 100° Cent. requires 90 units of heat, and to convert it into steam 540 units, or 630 units of heat altogether. A unit of heat being that required to raise the temperature of 1 gramme of water by 1° Cent.

A cubic inch of water weighs 16·359 grammes, and would require (16·359 × 630 =) 10,306 units of heat to convert it into steam.

The number of units of heat developed in an electric circuit is $RC^2 + 0{\cdot}4157$ per second, where R is the total electrical resistance and C is the current.

The writer used, for calculation, one of the dynamos belonging to the Defence Department of New Zealand as a source of electricity. When worked by a 25 horsepower engine at 800 revolutions per minute it gave a current of 100 ampères, with an electro-motive force of 60 volts, and its internal resistance was 0·375 ohm. It is therefore evident that the resistance of the conducting-cable must be kept as low as possible, and the writer assumed it at 0·625 ohm for facility of calculation (0·375 + 0·625 = 1 ohm).



m

Fig. 1.

The writer found that the best results were obtained when the resistance of the platinum wire in the water-cartridge was about equal to the rest of the resistance in the circuit: one-half of the total heat developed being then available for boiling the water. The resistance of the platinum wire should be, therefore, 1 ohm; and the total resistance 2 ohms. The current in the circuit C is ($E + R = 60 \div 2 =$) 30 ampères. Consequently ($RC^2 + 0{\cdot}4157 = 2 \times 30^2 + 0{\cdot}4157 =$) 4,330 units of heat will be developed per second; of which one-half, or 2,165 units per second, will be developed in the platinum wire.

One cubic inch of water will be converted into steam in (10,306 ÷ 2,165 =) 4·76 seconds, say 10 seconds, after allowing for loss of heat; and a few additional seconds will raise the steam to a high pressure. Theoretically, steam at a pressure of 150 lbs. per square inch should be produced in 5·30 seconds. If the size of the boiler or cartridge be increased, the force developed and the time for its production will be increased in the same ratio. For the proposed cartridge, the time would be theoretically (5·3 × 8·4 =) 44·5 seconds.

The naval pattern of iridio-platinum wire for firing mines is 0·003 inch in diameter, weighs 1·55 grains per yard, and is fused by a current of 1·65 ampères, having an electric resistance at the fusing-temperature of 2·96 ohms per inch.

In the boiler or cartridge, the current is 30 ampères, and the resistance is to be 1 ohm; the cross-section and weight of the wire to be used must, therefore, be increased in proportion (30 ampères : 1·65 ampères = 18·1 : 1) giving a wire about 0·0127 inch in diameter and weighing 28·18 grains per yard. The length of such a wire, giving the required resistance of 1 ohm, would be 6·1 inches.

Section of Boiler or Water-cartridge.—Fig. 1 illustrates the proposed boiler or water-cartridge, in which *m m*, is an iron boiler, ¾ inch in internal diameter, 3½ inches long, with a raised screwed thread ½ inch long on the inside of the upper and open end; *e*, is an ebonite, glass or porcelain plug, closing the cartridge after it is filled with water; *c c*, are conducting-wires embedded in the plug *e*; *p p*, is a platinum wire, 6·1 inches long, soldered to *c c*; and *s* is a wire stay embedded in *e* to keep *p p* in position. The cartridge should be covered with a woollen material, so as to diminish the loss of heat. The iron case or cartridge should be of such a thickness as to readily burst only when the required pressure is attained. The plug also must be able to withstand the desired pressure and accompanying temperature.

In loading a shot-hole, a little dry sand or similar substance should be placed behind and before the cartridge, so as to protect it from injury during tamping.

A vote of thanks was accorded to Major-General Schaw for his interesting paper.

The following paper by Mr. W. Carrick Anderson on "A Contribution to the Chemistry of Coal, with Special Reference to the Coals of the Clyde Basin" was taken as read:—

A CONTRIBUTION TO THE CHEMISTRY OF COAL, WITH SPECIAL REFERENCE TO THE COALS OF THE CLYDE BASIN.*

By W. CARRICK ANDERSON, M.A., B.Sc., Assistant to the Professor of Chemistry, Glasgow University.

Considering the advance that has been made during the last thirty years in the technical treatment of coal and the products of its destructive distillation, it appears somewhat remarkable that even at the present time so little should be known regarding the chemical nature of the bodies that go to constitute it. Apart from the value of coal itself as a fuel and as a reducing agent, its decomposition at more or less elevated temperatures gives rise to almost innumerable derivatives, and the subsequent treatment of these has in turn become the field of operation of extensive chemical industries. Many of the latter, although for the most part they date no further back than a single generation, have been, and are, among the most fruitful and profitable fields of chemical technology.

But it is obvious that if so important a subject of investigation as the mother-substances of the coal-tar products has remained so long neglected, there must be some special reason to account for this indifference. Such an explanation, and one more than adequate, is undoubtedly to be found in the extreme difficulty of gaining a footing from which to attack the problem, by reason of the insolubility of the great bulk of the constituent bodies in the ordinary chemical solvents and reagents.

Hence it has been the practice of most of those who have investigated the chemical nature of coal to seek enlightenment rather by way of the products of decomposition than by attempts to separate distinct chemical compounds from the naturally occurring substance. Even by such methods, it must be admitted, comparatively little information has been gained, and nothing that can be viewed in the light of conclusive evidence as to the fundamental structure of the bodies in question. Yet it is safe to say that no complete and satisfactory solution of the great

* Reprinted by permission of the Council of the Philosophical Society of Glasgow from their *Proceedings*, 1897-98, vol. xxix., page 72.

industrial problems of coal-distillation and coke-making can be hoped for, until some knowledge has been acquired regarding the nature of the substances which go to form the bulk of the class of minerals known collectively as coal. Only then can it be expected that the—even with all modern improvements—still excessive waste of the valuable nitrogenous constituent will come to an end,* and that the manufacture of coke, a manufacture daily increasing in importance, but at present one of the most unscientific chemical industries in the world, can be put on a thoroughly satisfactory basis.

It was in connexion with the latter problem more particularly that the writer undertook the investigation upon which he has been recently engaged, some of the results of which it may be worth while at this stage to place on record.

Although the scientific investigation of coal may be said to fall almost entirely within the last 40 years, it has for long been a matter of common knowledge that the minerals included under this generic title varied in properties to an almost unlimited extent, and particularly so in respect of the physical character of the residues left on igniting them in the absence of air. Mr. W. Stein † was the first to show that two coals may possess practically the same composition and yet yield carbonaceous residues entirely different in character and quantity—the one yielding a true "coke," and the other only "sintering," or even leaving a loose non-coherent powder.‡

Prof. Marsilly§ put forward the view that all caking coals from pits in which fire-damp occurs lose the property of caking on being heated to 300° Cent., and that if subsequently ignited in a closed crucible in powder they will yield a pulverulent residue. This result, as well as the observed fact that the caking property deteriorates when coals are allowed to be exposed to air, Prof. Marsilly explained by ascribing it to the volatilization of matter upon which the coking property depended.

Dr. Percy‖ stated that he had confirmed these observations by experiments on the strongly caking coal of Newcastle, which, after

* Dr. Knublauch (*Journal für Gasbeleuchtung*, vol. xxxviii., pages 753 to 758 and 769 to 773; also *Journal of the Society of Chemical Industry*, 1896, pages 106 and 107), who gives as the result of distilling Westphalian coal:—12 to 14 per cent. of the nitrogen converted into ammonia, not quite 2 per cent. into hydrocyanic acid, 30 per cent. as free nitrogen in the gas, and 50 per cent. left in the residual coke.

† *Chemische und Chemischtechnische Untersuchung der Steinkohlen Sachsens*, 1857.

‡ Dr. Percy, *Metallurgy*, vol. 1, "Fuel," page 308.

§ *Annales des Mines*, 1857, series 5, vol. xii., page 347 *et seq.*

‖ *Op. cit.*, page 309.

exposure to a temperature of 300° to 304° Cent. for one or two hours, no longer swells up and cakes on ignition, but yields only a slightly fritted coke. Dr. H. Fleck, at the time assistant to Prof. Stein at Leipzig, and afterwards professor at Dresden, came to the conclusion that the hydrogen in coal is partly united directly with the carbon and in part through the medium of oxygen. The former he designated "free" and the latter "combined hydrogen," and with the presence and relative proportion of the former he connected the property of caking and sintering possessed by certain coals. This view was combated in 1871 by Prof. E. Richters, of the Mining School at Waldenburg, who ascertained that in general the yield of coke is diminished if the coal contains much oxygen, and especially if a large percentage of hydrogen is present. Prof. Richters further established the fact that coal, on lying exposed to the air, and still more on gentle heating, readily absorbed oxygen with increase of weight, and with liberation at the same time of carbonic acid and water. Prof. Richters' work will be found in *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate*, 1871, and *Dinglers Polytechnisches Journal*, vols. cxci., cxciii., and cxcv., also in *Untersuchungen über die Veränderungen welche die Steinkohlen beim Lagern an der Luft Erleiden.*

In 1873, Prof. Gruner,* as the result of a large number of analyses of coals from various localities, came to the conclusion that a definite relation existed between the proportion of oxygen and hydrogen in the coal, the percentage of coke-residue left on ignition, and the physical properties of the latter, and this relation, he believed, could be made a basis of classification. Such an assumption, however, the researches of Messrs. Richters, Muck, and others have proved to be entirely unwarranted. The work of Dr. F. Muck, professor of chemistry in the Mining School at Bochum, added considerably to the knowledge of the subject. The results are principally contained in his *Chemische Aphorismen über Steinkohle*, published in 1873; *Chemische Beiträge zur Kenntniss der Steinkohle*, in 1876; and *Die Chemie der Steinkohle*, in 1881. With reference to the point of isomerism among coals, Dr. Muck showed by experiments upon the isomeric carbohydrates, starch, cellulose and gum, that differences in the physical character and weight of the fixed-carbon residue may be found in the case of other organic bodies of identical percentage-composition as well as in coal. For the substances mentioned he found the following :—

* *Annales des Mines*, 1874, series 7, vol. iv., page 169; and *Dinglers Polytechnisches Journal*, vol. ccxiii., page 244.

Starch.	Cellulose.	Gum.
Fixed carbon, 11·30 per cent.	6·71 per cent.	20·42 per cent.
Residue —Fused, strongly swollen.	Unfused, original form unchanged.	Denser and less lustrous than the former.

Regarding the origin of the property of coking, Dr. Muck expresses the following opinion :—" The property of melting or not melting depends on the presence or absence of certain carbon compounds, regarding which further knowledge will never be obtained, least of all in the way of quantitative estimation."*

In 1874, Dr. Dondorff pointed out the existence in certain Westphalian gas-coals of thin plates of a blackish substance possessing a reddish-brown colour in reflected light, which dissolved almost completely in ether, forming a light yellow, fluorescent solution. The quantity of this substance was very variable, and ranged from 0 to 0·3 per cent. of the coal matter. Prof. Dana† and Dr. Muck‡ refer to such soluble bodies, and differentiate between those extracted by various solvents. It may well be doubted, however, whether these bodies are anything more than mixtures. Other investigators in this line are Messrs. P. Siepmann,§ H. Reinsch,‖ P. Reinsch,¶ E. Guignet,** and Watson Smith.††

On treatment with liquid oxidizing agents all coals, even anthracites, are converted with more or less completeness into dark brown or black lustrous bodies, sparingly soluble in water, but very readily soluble in caustic alkalis, alkaline carbonates, and ammonia, forming intensely brown coloured solutions. These have been obtained by Dr. Schulze, of Rostock, by treating coal with chlorate of potash and nitric acid; by Prof. Jacobsen,‡‡ by the use of permanganate of potash and sulphuric acid; and by Mr. R. J. Friswell, §§ with dilute nitric acid. Mr. J. A. Smythe‖‖ has obtained chlorinated compounds of variable composition by treating coal with chlorate of potash and hydrochloric acid. Mr. Saville Shaw¶¶ treated coal for three weeks with a mixture of concentrated sulphuric and nitric acids, after which it was poured into a

* *Die Chemie der Steinkohle*, second edition, 1891, page 25.

† *Mineralogy*, page 745. ‡ *Die Chemie der Steinkohle*, second edition, page 66.

§ *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate*, 1891, vol. xxxix., page 26.

‖ *Journal für praktische Chemie*, 1880, series 2, vol. xxii., pages 188 to 191.

¶ *Dinglers Polytechnisches Journal*, vol. cclvi., pages 224 to 226.

** *Comptes Rendus*, vol. lxxxviii., pages 590 to 59?.

†† *Journal of the Society of Chemical Industry*, 1891, page 975.

‡‡ *Chemisch-technisches Repertorium*, 1877.

§§ *Proceedings of the Chemical Society*, 1891-92, page 9.

‖‖ "Proximate Constituents of Coal: Report of the Committee," *Report of the British Association for the Advancement of Science*, 1896, page 340. ¶¶ *Ibid.*

large bulk of water. The carefully washed and dried residue showed little change in outward appearance, but gave 77 per cent. of volatile matter on ignition, as compared with 27 per cent in the original coal.

On the general question, the following papers and works may also be referred to:—Prof. E. J. Mills' "Cumulative Resolution;" * the same author's *Destructive Distillation*, first edition, 1877, fourth edition, 1897; Messrs. Cross and Bevan, "Chemistry of Bast Fibres;"† and Messrs. Schinnerer and Morawsky.‡

The coals in the upper part of the Clyde basin series are entirely non-coking in character, and those lying between the position of the Palace Craig ironstone and the Airdrie Blackband ironstone are not used for coking purposes in any part of the district.

The Ell coal is a bright black coal with cubical fracture and a brownish ash. It usually contains some hard ribs of splint-coal and a portion of the seam is contaminated with nodules of iron pyrites ("brasses"). The vertical "backs" are usually filled with a thin layer of calcareous matter, which seems to have been deposited from solution in water. The coal is brittle, and soon breaks up on exposure to the weather. It is a good household coal, and where found in its best condition the large coal is sold exclusively for this purpose. The small coal is a valuable fuel for steam-raising. A few attempts have been made to manufacture metallurgical coke from the small coal, but they have not been successful.

The Pyotshaw coal is very variable in quality and thickness, is similar in character to the Splint coal described below, but is much coarser in appearance and contains more ash.

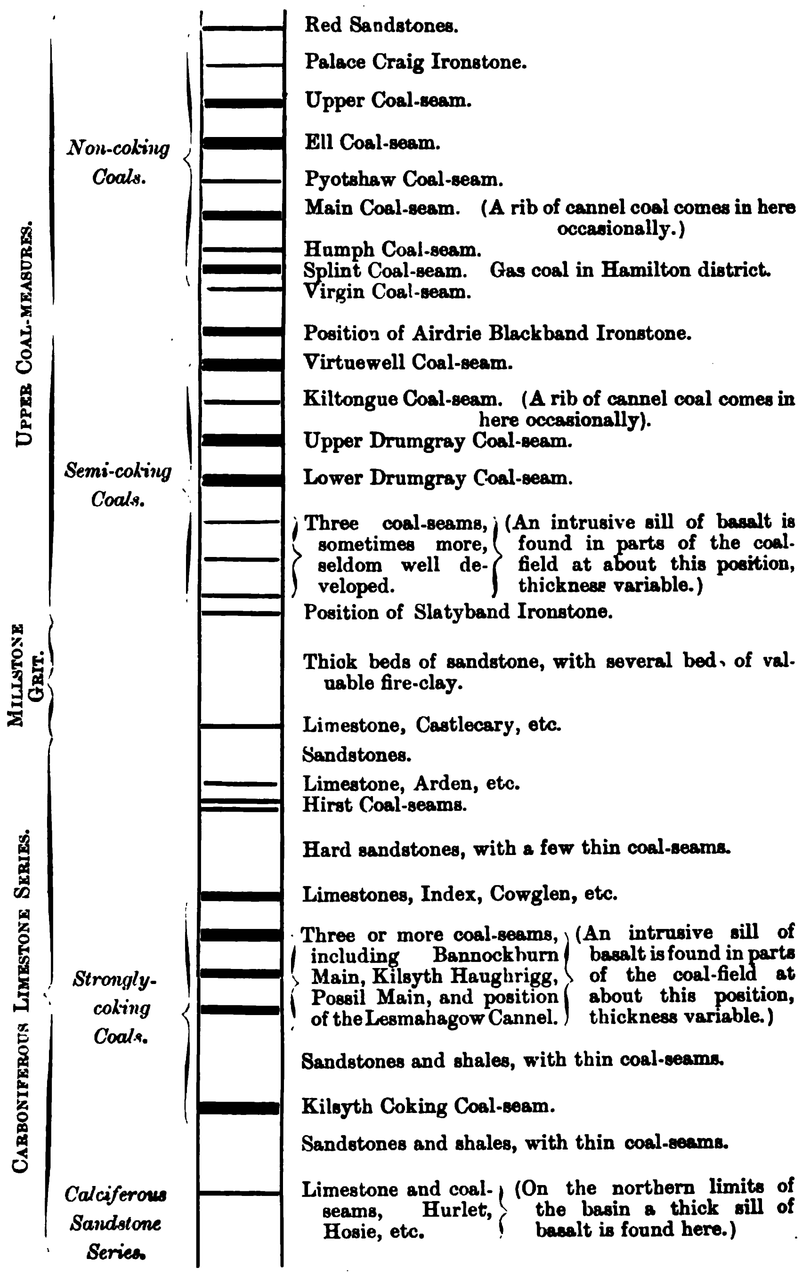
The Main coal is a bright black coal with cubical fracture and a white ash. It contains, as a rule, three ribs of hard splinty coal of considerable thickness In some districts a rib of cannel coal of fair quality is present, and over a large area the thickest splinty rib, called the "pugs," is found to yield a fair quantity of gas of about 19 candle-power. The hard ribs are for the most part used for gas-making, and the bright black coal is a fair household coal. The vertical "backs" are filled with a calcareous deposit as in the Ell coal. The coal is very brittle, and soon falls to pieces on exposure to the weather. This coal is never used for the manufacture of metallurgical coke. The portion used for gas-making, when distilled in the retorts, yields a soft, friable coke of little value.

* *Philosophical Magazine*, 1877.

† *Journal of the Chemical Society*, vol. xli., pages 90 to 110.

‡ *Berichte der deutscher Chemische Gesellschaft*, vol. iv., page 185.

General Section of the Clyde Coal-basin.



The Splint coal is hard and strong, and possesses a dull blue-black colour. It splits easily along numerous beds parallel to the plane of stratification, but is difficult to break vertically except at the "backs," which, as a rule, are not numerous, so that this coal is got in large lumps, which do not readily fall to pieces even after exposure to the weather. It is chiefly used for smelting iron in blast-furnaces and for gas-making. It is never coked.

The Cannel coal, which in the Hamilton district is found separating the Splint coal from the Virgin coal, is a hard, brittle coal with smooth conchoidal fracture. There is usually a rib of bright coal between the Splint and the Cannel, which does not readily part from the latter, and the change from bright black coal to Cannel is not marked by a distinct line or bed of stratification, although the change is sharp. This seems to indicate that, whatever may have been the process by which these two qualities were produced, the change of conditions was sudden, but the process continuous, perhaps a change in the nature of the vegetable substance.

Virgin coal is a bright black coal, coarser and stronger than the Ell coal. It is a fair household coal, and is not used for coke-making.

Virtuewell coal is similar in appearance to the Virgin coal. In some districts it is a first-class house coal, and is sometimes used to make an inferior quality of coke.

Upper Drumgray coal is, as a rule, a hard blue-black coal, suitable for furnace purposes. In the Slamannan district, the intrusive basalt seems to have materially affected the quality of this seam, converting it into a steam-coal of very good quality. In many places the small has been used for coking purposes, and, where the action of the basalt has not been excessive, it is a valuable coking-coal. The near approach of the basalt has in some places destroyed the coking properties and rendered the coal semi-anthracitic.

The Lower Drumgray is a bright black coal, sometimes a first-class house-coal, but always much softer than the Upper Drumgray. Like the Upper Drumgray, it is altered in character by the intrusive basalt, and the same remarks apply.

The remaining seams above the Slatyband ironstone are developed to a workable extent only in the eastern portion of the Clyde basin, chiefly in the district between Shotts and Falkirk. Their quality is, as a rule, inferior, and they are subject to the above-mentioned action of the intrusive igneous rock. At their best, an inferior coke is made from the small.

From the Slatyband ironstone to the position of the Index limestone the few coals which are found are inferior in quality.

Below the Index limestone is a group of coal-seams of a strong coking quality, well developed and largely worked on the northern outcrop of the basin, but of little value on the south. The seams vary very much in thickness, and it is not possible to trace each one for any distance. All that can be safely affirmed is that the Possil Main, Kilsyth Haughrigg, Bannockburn Main, Kinneil and Wilsontown Main are the thickest seams of this group in their respective districts. In appearance they are all more or less alike. They are soft black coals of irregular fracture, easily affected by exposure to the weather, and have not the calcareous deposit mentioned above filling the fractures. Where the intrusive basalt is absent or remote, these coals will all make coke, the quality of which varies, but in general it is hard, with a strong metallic ring, and much superior for metallurgical purposes to that made from the coal of the Upper Coal-measures. Where the intrusive basalt is near, the coking properties are destroyed, and the coal becomes semi-anthracitic, and in a few cases a true anthracite with glassy fracture is produced.

Kilsyth Coking or Banton Main coal has a well-defined position over a large area, but is best developed in the immediate neighbourhood of Kilsyth. The characteristics are similar to the above, and from it a first-class coke is made.

In the investigations which the writer undertook with a view more particularly to finding out points of difference in character and reaction between coals which might be regarded as non-coking * and those which are true coking varieties, he experimented upon samples of the principal seams belonging to the upper and lowest divisions of the Clyde basin series carefully selected for him by Mr. Wallace Thorneycroft, of the Merryton and Plean collieries, to whom he would here express his cordial thanks for much valuable assistance. He desired further to acknowledge the loyal co-operation of his friend Mr. James Roberts, of the University Laboratory, who from first to last has ably assisted him in carrying out these experiments.

In the Clyde basin it may be generally affirmed that the coking property increases with depth, although this cannot be predicated as a constant feature of all coal-fields.

* In this paper, the writer uses the term "non-coking" as meaning nothing more than that such coals are not capable of being employed for the manufacture of metallurgical coke. As a matter of fact, all the coals referred to above "coke" to the extent of giving coherent residues on ignition.

The subjoined tables give the ultimate and proximate analyses of the samples employed; the relative stratigraphical position of the seams will be seen by referring to the preceding geological section.

TABLE I.—ULTIMATE ANALYSES OF COALS.

Coals.	Hamilton District.					Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Ell.	Main.	Splint.	Gas.	Virgin.			
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Hydrogen ...	4·52	4·98	4·82	5·54	5·10	5·06	5·14	5·20
Carbon	71·88	73·62	75·50	76·16	74·67	80·67	82·80	81·50
Oxygen	11·10	9·50	8·71	7·52	8·62	7·50	5·67	7·53
Nitrogen .	1·53	1·54	1·50	1·52	1·54	1·84	1·89	2·04
Moisture ...	9·99	9·08	7·27	5·56	7·77	1·98	1·75	1·72
Ash	0·98	1·28	2·20	3·70	2·30	2·95	2·75	2·01
Totals ...	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE II.—COMPOSITION OF ABOVE COALS CALCULATED ON DRIED SAMPLES.

Coals.	Hamilton District.					Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Ell.	Main.	Splint.	Gas.	Virgin.			
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Hydrogen ...	5·02	5·47	5·20	5·87	5·53	5·16	5·23	5·29
Carbon	79·87	80·97	81·42	80·63	80·97	82·30	84·28	82·93
Oxygen	12·33	10·45	9·39	7·97	9·34	7·65	5·77	7·66
Nitrogen ..	1·70	1·71	1·62	1·61	1·67	1·88	1·92	2·08
Ash	1·08	1·40	2·37	3·92	2·49	3·01	2·80	2·04
Totals ..	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE III.—COMPOSITION OF THE DRY ASH-FREE COALS, CALCULATED FROM THE FOREGOING.

Coals.	Hamilton District.					Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Ell.	Main.	Splint.	Gas.	Virgin.			
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Hydrogen ...	5·07	5·56	5·32	6·11	5·67	5·32	5·38	5·40
Carbon	80·74	82·13	83·41	83·92	83·03	84·86	86·70	84·67
Oxygen	12·47	10·59	9·62	8·29	9·59	7·89	5·94	7·82
Nitrogen ...	1·72	1·72	1·65	1·68	1·71	1·93	1·98	2·11
Totals ..	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Combined * Hydrogen ...	1·56	1·32	1·20	1·04	1·20	0·98	0·74	0·98
Disposable Hydrogen ...	3·51	4·24	4·12	5·07	4·47	4·34	4·64	4·42
Ratio $\frac{\text{Disposable H}}{\text{1,000 carbon}}$	43·47	51·62	49·39	60·41	53·84	51·15	53·50	52·20

* These relations have been founded upon as affording a constant and well-marked distinction between coking and non-coking coals. It is true that generally in coking coals the percentage of so-called combined hydrogen (oxygen ÷ 8) is lower than in non-coking; but it will be obvious, from a comparison of these figures with those in Tables IV. and VI., that no reliance can be placed upon such data as an index to the degree of coking power, or even to the percentage-yield of "fixed carbon."

TABLE IV.—PROXIMATE ANALYSES OF THE ABOVE SAMPLES.

Coals.	Hamilton District.					Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Ell.	Main.	Splint.	Gas.	Virgin.			
	Per Cent	Per Cent.	Per Cent	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Moisture ..	9·99	9·09	7·27	5·56	7·77	1·98	1·75	1·72
Ash	0·98	1·28	2·20	3·70	2·30	2·95	2·75	2·01
Volatile matter	33·33	35·84	36·22	38·25	33·53	32·55	27·40	28·45
Fixed carbon ...	55·70	53·79	54·31	52·49	56·40	62·52	68·10	67·82
Totals ..	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE V.—SPECIFIC GRAVITIES AND CALORIFIC VALUES.

Coals.	Hamilton District.					Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Ell.	Main.	Splint.	Gas.	Virgin.			
Specific gravity	1·266	1·261	1·292	1·290	1·286	1·291	1·306	1·275
Calorific value (Thompson's calorimeter) ...	7,480	7,590	7,425	7,370	7 480	7,535	7,865	7,810

For the purpose of obtaining a comparative estimate of the caking power of these coals the writer employed the simple test given by Mr. Louis Campredon, which consists in igniting 1 gramme of the coal with the largest quantity of fine white sand which it is capable of binding into a mass that just coheres. The weight of sand in grammes is the "caking index." Tested in this way the samples gave the following results recorded in Table VI.

TABLE VI.

Coa	Hamilton District.					Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Ell.	ain.	Splint.	Gas.	V rgin.			
Caking index ...	4 +	4	3·5	3·5 –	4	9 +	15·5	16 +

The last three are true caking coals, and are all used for the production of high class foundry coke. In the crucible they give strongly-swollen, hard, metallic-looking "cokes." The Main and Ell coals give slightly swollen coke-residues in the crucible, while the residues from the Splint, Gas and Virgin seams are flat or slightly concave cakes of less bulk than the original coal. None of these is anywhere employed for coke-making.

Extraction with Solvents.—In the endeavour to find some difference between the two classes of coking and non-coking coals, recourse was had

in the first instance to the use of solvents. After some preliminary trials, it was resolved to extract first of all with cold gasoline, and afterwards to further treat with cold carbon disulphide. In the first case the dried samples (20 grammes) were left in contact with 200 cubic centimetres of the solvent for six days with frequent shaking. The gasoline-solutions were of a pale yellow colour with strong blue fluorescence, and on evaporating off the solvent the residual extracts were found to be almost completely volatile at 99° Cent. The extracts were pale yellow oils similar to one another in appearance, except that from Bannockburn Main coal which was darker in colour and more viscous.

The samples freed from gasoline were allowed to remain in contact with cold carbon disulphide (200 cubic centimetres) for ten days. The solutions were of a dark yellow colour with faint greenish fluorescence, and, on evaporating off the solvent, dark-brown solid bodies were left, which possessed a distinctly resinous odour. These extracts were only slightly volatile at 99° Cent.

TABLE VII.

Sample.	Weight of Gasoline Extract after 1½ hours at 99°.	Weight of Gasoline Extract after 7½ hours at 99°.	Weight of Carbon Disulphide Extract after 1½ hours at 99°.	Weight of Carbon Disulphide Extract after 7½ hours at 99°.
Hamilton District—	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Ell	0·878	0·071	0·448	0·428
Main	0·851	0·141	0·659	0·609
Splint	0·620	0·046	0·468	.0·445
Gas	0·498	0·105	0·537	0·518
Virgin	0·584	0·061	0·497	0·477
Kilsyth Haughrigg ..	0·524	0·048	-	—
Bannockburn Main ...	0·453	0·150	0·881	0·699
Kilsyth coking ...	1·355	0·062	0·466	0·402

TOTAL EXTRACTED MATTER (GASOLINE AND CARBON DISULPHIDE).

Coals.	Per Cent.	Coals.	Per Cent.
Ell	1·326	Virgin	1·081
Main	1·510	Haughrigg	—
Splint...	1·088	Bannockburn Main... ...	1·334
Gas	1·035	Kilsyth coking	1·821

The bodies thus obtained are doubtless similar in character to those obtained by Messrs. Muck, Siepmann, and others; but as it was found that they were not present in greater quantity in coking than in non-coking coals, and that, moreover, their removal exercised little, if any, deteriorating effect upon the coking property, the investigation of them was not pursued further.

Treatment with Caustic Potash.—A gramme of each of the coals was boiled for one hour with 100 cubic centimetres of a 5 per cent. solution of caustic potash, and the residue filtered off and carefully washed till free from alkali. In the case of Ell, Main and Virgin coals, the filtrate was dark coffee-brown in colour, and from it a small quantity of a brown humus-like substance was precipitated on acidifying. Splint and Gas coals gave a pale amber-coloured filtrate, while the true coking-coals gave only the faintest trace of colour, more distinct in the case of Haughrigg than in the other two.

On igniting these extracted samples in a closed crucible in the usual way, it was found that in the case of the first five all tendency towards cohesion had disappeared, and the residues were loose, dull, earthy-looking powders, several per cents. higher in weight than the "cokes" got from the dry untreated coal. In the case of the three coking-coals, boiling for even three hours with 5 per cent. caustic potash appeared to cause very little deterioration in the coke.

Treatment with Nitric Acid.—Having found that boiling with dilute potash gave different results (colour of solution and condition of coke-residue) with different coals, recourse was had next to nitric acid. Two grammes of the dry coal were mixed with 25 cubic centimetres of nitric acid (specific gravity 1·4) in a small beaker packed in cottonwool, and the rise in temperature was noted. In each case the rise ceased in about 7 minutes; and in the case of the Main coal in 5 minutes.

TABLE VIII.

Coals.	Degrees Cent. Rise.	Coals.	Degrees Cent. Rise.
Ell	17·00	Virgin	15·25
Main	17·75	Kilsyth Haughrigg	17·00
Splint	13·50	Bannockburn Main	17·00
Gas	13·25	Kilsyth coking	17·00

One gramme of each coal was evaporated to dryness with 20 cubic centimetres of dilute nitric acid (specific gravity 1·2) on a water-bath,

TABLE IX.

Coals.	Increase in Wt. = Per Cent.	Per Cent of Dry Coal.
Ell	10·33	11·47
Main	9·52	10·47
Splint	16·61	17·91
Gas	15·42	16·33
Virgin	12·17	13·19
Kilsyth Haughrigg	18·16	18·53
Bannockburn Main	23·31	23·73
Kilsyth coking	23·10	23·51
Bannockburn Main, after previous partial oxidation in air till coking power had been completely lost	9·98	9·98

and the residue dried at 105° Cent. till constant. In each case a gain in weight was recorded, but these differed considerably in amount.

Oxidation of Coal.—The researches of Prof. Richters proved that there is present in coals a constituent capable of undergoing easy oxidation, especially at slightly elevated temperatures. This oxidation causes the coal to increase in weight so long as it is carried on below a limit which in the generality of cases may be put at about 190° Cent., beyond which point the volatilization of certain constituents causes usually a net loss in weight. The following results will show to what extent this takes place in a coking and non-coking coal. In each case 1 gramme, in a finely powdered condition, was heated in a porcelain crucible packed in asbestos within a larger one of metal.

TABLE X.

Coals.	Heated for 4 hours at 300° Cent. Loss. Per Cent.	Residue Ignited. Further Loss. Per Cent.
Bannockburn Main	44·02 ...	12·50
Gas	56·98 ...	8·40
	Heated for 4 hours at 250° Cent. Loss.	Residue Ignited. Further Loss.
Bannockburn Main	17·08 ...	25·94
Gas	31·82 ...	18·46
	Heated for 4 hours at 200°-205° Cent. Loss.	Residue Ignited. Further Loss.
Bannockburn Main	3·94 ...	28·06
Gas	14·84 ...	31·00
	Heated for 1 hour at 160° Cent. Gain.	Weight of Residue left on Ignition.
Bannockburn Main	1·98 ...	78·02
Gas	·90 ...	59·96

Bannockburn Main coal, heated for 33 hours in an air-bath at 115° to 120° Cent., showed a gain in weight of 1·96 per cent. The weight of the residue left on ignition was 75·66 per cent.

The ignited residues from both Bannockburn Main and Gas coals, after these had been heated for 4 hours at 300° Cent., cohered below, but were in the form of loose, dull powder above. In the other experiments the residues left by both were loose powders without any trace of cohesion, even when the previous heating was only for 1 hour at 160° Cent. The gases given off on ignition in these cases were non-luminous, and the residues showed on the surface a thin layer of finely-divided carbon in the form of small rods, apparently resulting from the decomposition of a complex carbon compound.

In order to make certain that this loss of coking property was due only to oxidation, and was not a result induced by simple heating at

comparatively low temperatures, the experiment was repeated with Bannockburn Main coal at 160°, in an atmosphere of carbon dioxide. Two experiments gave, instead of a gain as above, losses of 1·77 and 1·85 per cent., and the residues on ignition left a bright silvery coke, similar to those got from the original coal, and weighing 74·5 per cent. of the heated sample. Similar results were got with Kilsyth Coking and Kilsyth Haughrigg coals.

To show the rate at which this oxidation proceeds, the results of heating 1 gramme of powdered Bannockburn Main coal in an air-bath at 140° to 150° are recorded in Table XI.

TABLE XI.—BANNOCKBURN MAIN COAL HEATED IN AIR AT 140° TO 150° CENT.

Time.		Percentage Gain in Weight.
In first 7 hours	... ...	1·012
In next 22 hours	... ...	1·335
In next 26½ hours	... ...	0·857
In next 42½ hours	... ...	0·874
In next 47 hours	... ...	0·621
In next 57 hours	... ...	0·467
Total... 202 hours.	Total gain ...	5·166

The effect of this oxidation upon the composition of the coal is seen below:—

	Original Composition of Coal. Per Cent.	After Oxidation as above. Per Cent.
Hydrogen	5·39	4·49
Carbon	86 70	78·16
Oxygen and nitrogen	7·91	17·35
	100·00	100·00

The fixation of oxygen is accompanied by an evolution of carbon dioxide and water. A comparison of the rate at which both processes go on at different temperatures was made by heating samples of Bannockburn Main coal at 99° Cent. and at 160° Cent., with the results shown in Table XII.

TABLE XII.—DRY BANNOCKBURN MAIN COAL, HEATED FOR 54 HOURS AT 99° CENT. (WEIGHT OF SAMPLE, 2·7605 GRAMMES).

Time.	Gain in Weight of Sample. Gramme.	Water produced. Gramme.	Carbon Dioxide produced. Gramme.
First 6 hours ...	− 0·0049	+ 0·0035	+ 0·0008
Second 6 hours ..	− 0·0030	+ 0·0156	+ 0·0004
Third 6 hours ...	+ 0·0020	+ 0·0076	+ 0·0006
Fourth 6 hours ...	+ 0·0038	+ 0·0124	+ 0·0000
Fifth 6 hours ...	− 0·0046	+ 0·0106	+ 0·0016
Sixth 6 hours ...	− 0·0098	+ 0·0062	+ 0·0014
Seventh 6 hours ...	+ 0·0016	+ 0·0074	+ 0·0014
Eighth 6 hours ...	− 0·0012	+ 0·0170	+ 0·0020
Ninth 6 hours ..	− 0·0068	+ 0·0096	+ 0·0010
Total...54 hours.	Net loss, 0·0139 grm. = 0·503 per cent.	H_2O = 0·0899 H = 0·0100	CO_2 = 0·0092 C = 0·0025

The residue on ignition gave a good, strongly swollen coke, weighing 73·36 per cent.

TABLE XIII.—DRY BANNOCKBURN MAIN COAL, HEATED FOR 60 HOURS AT 160° CENT. (WEIGHT OF SAMPLE, 2·6910 GRAMMES).

Time.	Gain in Weight of Sample. Grammes.	Water produced. Grammes.	Carbon Dioxide produced. Grammes.
First 6 hours	+ 0·0191	0·0196	0·0052
Second 6 hours	+ 0·0210	0·0350	0·0136
Third 6 hours	+ 0·0140	0·0240	0·0174
Fourth 6 hours	+ 0·0118	0·0166	0·0090
Fifth 6 hours	+ 0·0128	0·0188	0·0132
Sixth 6 hours	+ 0·0090	0·0194	0·0104
Seventh 6 hours	+ 0·0062	0·0176	0·0094
Eighth 6 hours	+ 0·0080	0·0186	0·0104
Ninth 6 hours	+ 0·0030	0·0160	0·0122
Tenth 6 hours	+ 0·0034	0·0166	0·0110
Total...60 hours.	Total gain, 0·1083 = 4·025 per cent.	Tl. H_2O = 0·2022 H = 0·0224	Tl. CO_2 = 0·1118 C = 0·0305

The residue when ignited did not coke, but left a loose, dull powder, weighing 74·08 per cent.

The experiments with caustic potash and with nitric acid described above, as well as the calorific values and coking indices of the coals, suggested that they may be divided into three classes—the first represented by Ell and Main, the second by Splint and Gas, and the third by Bannockburn Main and Kilsyth Coking coal. The Virgin coal seemed to stand midway between the first and second classes, and Kilsyth Haughrigg between the first and third. The percentages of nitrogen found in the samples appeared further to support this view. In the endeavour to ascertain how far it was correct, it appeared possible that some light might be got by carrying out the oxidation of the coals to the limits represented by their ceasing to gain in weight, and afterwards determining the composition of the products. Prof. Richters* showed by his experiments that this gain in weight goes on up to a point beyond which a slight decrease is noted, and then the weight remains apparently constant. In the specimens which he employed he found that the maximum weight was reached after 20 hours' heating at 180° to 200° Cent. In carrying out the operation upon the above-mentioned samples, the writer found that the oxidation went on very rapidly during the first 12 to 24 hours, but that thereafter a slow increase in weight continued for a long time, and that the period required to complete the process (and also the increment in weight) varied greatly in the different coals.

* *Dinglers Polytechnisches Journal*, vol. cxcv., page 315.

TABLE XIV.—NUMBER OF HOURS REQUIRED FOR OXIDATION AND NETT GAIN IN WEIGHT OF COALS.

Coals.	Hamilton District.					Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Ell.	Main.	Splint.	Gas.	Virgin.			
Hours required to complete oxidation	47	40	35	33	49	49	78	112
Nett gain in weight of coal per cent. ...	4·15	3·95	3·92	3·82	4·23	5·13	6·44	6·79

The composition of the resulting oxidized products is seen from Table XV. In each case the coal was heated for 6 hours after the increase in weight had ceased.

TABLE XV.—COMPOSITION OF BODIES GOT BY OXIDIZING COALS IN AIR AT 180° TO 190° CENT. TILL THE GAIN IN WEIGHT HAD CEASED.

Coals.	Hamilton District.					Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Ell.	Main.	Splint.	Gas.	Virgin.			
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Hydrogen ...	3·92	3·95	4·35	4·45	3·97	3·88	3·90	3·90
Carbon ...	71·44	71·19	74·33	71·84	71·67	71·35	75·84	74·75
Oxygen and nitrogen ...	23·54	23·53	19·04	19·96	22·34	21·80	17·75	19·60
Ash	1·10	1·33	2·28	3·75	2·02	2·97	2·51	1·75
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE XVI.—COMPOSITION OF ASH-FREE ORGANIC MATTER IN THE ABOVE BODIES.

Coals.	Hamilton District.					Kilsyth Haugh-rigg	Bannock-burn Main.	Kilsyth Coking.
	Ell.	Main.	Splint.	Gas.	Virgin.			
	Per Cent.	Per Cent.	Per Cent	Per Cent.	Per Cent.	Per Cent.	Per Cent	Per Cent.
Hydrogen ...	3·97	4·00	4·45	4·63	4·05	4·00	4·00	3·97
Carbon ...	72·23	72·15	76·07	74·63	73·15	73·53	77·79	76·08
Oxygen and nitrogen ...	23·80	23·85	19·48	20·74	22·80	22·47	18·21	'9·95
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

Products of Oxidation with Nitric Acid.—In order to examine further the difference between these classes of coal substances by the method of oxidation, an attempt was made to prepare, in a partially purified condition, the brown acid bodies got by acting on Ell, Splint and Bannockburn Main coals with nitric acid. About 5 grammes of each were evaporated to dryness over the water-bath with 200 cubic centimetres of nitric acid (specific gravity 1·2), the residue was dissolved as far as possible by ammonia, and the filtered solution reprecipitated by hydrochloric acid. This process was repeated, and the insoluble acids

were frequently washed by decantation. The bodies thus obtained are insoluble in water containing mineral acids or salts in solution, but are fairly soluble in pure water. They were afterwards thrown on a filter, washed as far as possible with water, and finally dried for some days at 105° Cent. The acids from all three coals contained nitrogen and sulphur, and had the composition recorded in Table XVII.

TABLE XVII. COMPOSITION OF ACID BODIES PREPARED FROM COAL WITH NITRIC ACID.

	Hamilton District. Ell Acid. Per Cent.		Hamilton District. Splint Acid. Per Cent.		Bannockburn Main Acid. Per Cent.
Hydrogen	3·15	...	3·20	...	3·33
Carbon	58·45	...	62·31	...	62·64
Oxygen, nitrogen and sulphur	37·87	...	33·14	...	33·40
Ash	0·53	...	1·35	...	0·63
	100·00	...	100·00	...	100·00

TABLE XVIII.—COMPOSITION OF ORGANIC MATTER IN THE ABOVE.

	Hamilton District. Ell Acid. Per Cent.		Hamilton District. Splint Acid. Per Cent.		Bannockburn Main Acid. Per Cent.
Hydrogen	3·17	...	3·24	...	3·35
Carbon	58·76	...	63·17	...	63·05
Oxygen, nitrogen and sulphur	38·07	...	33·59	...	33·60
	100·00	...	100·00	...	100·00

Effect of Heat on the Coking Property.—Dr. Percy* quotes an assertion of Prof. Marsilly† to the effect that "all caking coals from pits in which fire-damp occurs cease to swell up and cake when they have been previously heated to 300° Cent.; so that when they are heated to redness in a covered crucible in the state of powder, after having been heated to 300° Cent., they will be found in the state of powder afterwards." The correctness of this assertion, he states, he has confirmed with respect to the strongly-caking coal of Newcastle-upon-Tyne. "The powder of this coal was heated in the hot-air bath at a temperature varying between 300° and about 304° Cent. It may be thus heated for about ¼ hour without sensibly losing its property of swelling up and caking; but when it is kept exposed to this temperature during 1 or 2 hours, it does not swell up when subsequently heated to redness, and yields only a very slightly fritted coke."

Prof. Marsilly infers that the loss of the caking property which takes place when coal lies exposed to air for a lengthened period, and also when it is subjected to the action of heat under 330° during a short time, is due to the same cause, viz., volatilization of matter upon which the coking property depends.

* *Metallurgy*, vol. i., "Fuel," pages 308 and 309. † *Loc. cit.*

Now it has been shown above that, if precautions be not taken to exclude air from contact with the coal, a temperature very much lower than 300° Cent. suffices in 1 or 2 hours to destroy completely any tendency towards caking in such high-class coking coals as that of the Bannockburn Main seam and Kilsyth Coking, but that this is not due to volatilization of the constituent which conditions the caking, but to its oxidation. It does not appear that either Prof. Marsilly or Dr. Percy took such precautions, and therefore the chief agent at least in producing the results which they observed was, in all probability, atmospheric oxygen. To test the assertion further, however, samples of the above coals, coking and non-coking, were subjected to a temperature of 297° to 304° Cent. for 3 hours in a U tube, through which was passed a slow current of dry carbonic acid gas. The results are recorded in Table XIX.

TABLE XIX.—RESULTS OF HEATING COALS TO 300° CENT. IN CARBONIC ACID.

Coals.	Hamilton District.					Kilsyth Haughrigg.	Bannockburn Main.	Kilsyth Coking.
	Ell.	Main.	Splint	Gas.	Virgin.			
Percentage loss of dry coal on heating ...	9·5	16·2	16·2	21·8	17·7	13·1	7·3	6·4
Weight of residue after ignition (residue at 300° C. = 100) ...	71·18	74·56	73·43	79·68	72·13	79·33	76·98	72·87
Weight of ignited residue from dry coal ...	62·97	60·50	60·94	59·50	63·60	66·80	72·12	71·03
Increase	8·21	14·06	12·49	20·18	8·53	12·53	4·86	1·84
Physical condition of ignited residue from coal heated to 300° Cent.	A considerable part in form of a dull earthy coke; the rest in powder.	The residues from these four coals just cohered and no more.				Residue formed a coke, but this was dull and not swollen up.	Residues completely coked, but of a duller appearance than before.	

From these figures it may be observed—

(1) That the greatest loss at 300° Cent. takes place in Splint, Gas, Virgin and Main coals—that is, in the long-flaming coals, which have also the lowest coking index; the smallest loss is found in the strongest caking coals, Bannockburn Main and Kilsyth Coking (caking indices, 15·5 and 16), while Ell and Kilsyth Haughrigg, which swell up slightly on ignition in a crucible, occupy an intermediate position.

(2) That the percentage of coke or fixed residue rises enormously after the coal has been heated to 300° Cent.

(3) That in the coals of which the ignited residues cohered only slightly, and which show the largest percentage loss at 300° Cent, the

tendency to cohere is completely destroyed; while in the case of the true coking-coals it is, though impaired to some extent, still existent.

These facts, taken along with others previously mentioned, are, the writer believes, capable of a very simple explanation. In all the coals mentioned we have a set of bodies of a resinoid character, which are capable of extraction with dilute caustic-potash solution, and which alone are accountable for the tendency to cohere in the residue from the Ell, Main, Splint, Gas and Virgin coals. These bodies are not the same in each coal, but vary alike in kind and in quantity. They contribute only to a very slight extent to the weight of the fixed residue got on ignition, being, for the most part, driven off, and constituting a large part of the "smoke," to which they contribute a characteristic smell. They are all more or less completely volatilized below 300° Cent., except in the case of the Ell, where a part seems to remain behind, causing the partial coking of the residue on ignition.

In addition to these, there is in the true coking-coals a constituent, or a series of constituents, not so readily, if at all, acted on by dilute alkaline solutions, oxidizable, like the main constituent of the non-coking coals, in air, but not volatile at 300° Cent. The writer has found that both Bannockburn Main and Kilsyth Coking coals melt in an atmosphere of carbon dioxide at a definite point, which may be placed at 317° Cent., and this he takes to be the melting-point of the constituent referred to. In all probability the higher percentage-yield of fixed residue usually found as an accompaniment of the coking-coals, and which Prof. Gruner believed to be a universal characteristic, is due to the fact that this body, or class of bodies, breaks down on heating into fixed carbon and simpler compounds before being itself volatilized. Active gasification does not appear to begin below 330°, and is not particularly vigorous even at this temperature. The evolution of gas at this stage is perhaps to be traced to the decomposition of the other kind of constituent present in coal minerals, and not to breakdown of the fusible body, which may decompose only at a considerably higher temperature.

Presence of Free Carbon in Coal.—In this paper the writer desires to avoid anything in the way of abstract theorizing on a subject on which, it seems to him, much more experimental work is required before elaborate theories can be of any service. He would advert briefly, however, to a point of some importance, namely, the existence or non-existence of elemental carbon in coals. The view at present almost universally held is that free carbon does not constitute any part of the matter of ordinary

coal minerals, and from this view he is not prepared to dissent. At the same time, the point is one on which conclusive evidence is not forthcoming, and is perhaps at the present moment scarcely to be looked for. Dr. Muck* advances the fact that, after treatment with nitric acid, coals go almost completely into solution in the form of humus-like bodies containing hydrogen and oxygen as proof that they do not contain carbon as such. But that such evidence is not unimpeachable may be seen by comparing the humus-like acid bodies in Table XVIII., derived in this way from coals, with graphitic acid,† which has the composition:—

	Per cent.
Hydrogen	1·85
Carbon...	61·11
Oxygen	37·04
	100·00

and which was prepared by Dr. Brodie by the action of chlorate of potash and nitric acid on graphite: in this case graphite, a form of native carbon, has been converted by oxidation into a compound containing both hydrogen and oxygen.

The fact that strongly-ignited cokes still contain hydrogen, oxygen and nitrogen is an argument of no greater validity, since it might well be that stable compounds of these elements with carbon existed side by side with the latter in the free state.

If, on the other hand, it should turn out, as will probably be found to be the case, that all the acid bodies obtained as above, by the action of nitric acid on coal, contain nitrogen, and if these can be proved to be simple chemical substances, and not mixtures of two or more, it is a reasonably safe deduction that they are produced by the oxidation of a compound containing nitrogen, which constitutes the bulk of the organic matter of the coal.

With regard to the results of these experiments as a whole, and to the conclusions to be drawn from them, no validity can be claimed at present beyond the particular samples from which they were got. They establish the fact, however, that not only does a difference exist in the degree of the coking property between the coals of the uppermost series of the Clyde basin and those of the lowest, but that this difference is due to the presence of a constituent in the latter which is absent in the former, or is at least present only in very small quantity. The melting point of this constituent is, as near as may be ascertained, 317° Cent. The main

* *Die Chemie der Steinkohle*, second edition, page 152.

† *Philosophical Transactions*, 1859, page 249.

cause of the sintering of the non-coking coals of the upper series is undoubtedly to be found in the resinoid (saponifiable) constituents, which are volatilized completely in a current of dry carbon dioxide at 300° Cent., with the exception of a small part which still remains in Ell coal at that temperature. Such bodies contribute to some extent likewise to the coking property in the true coking-coals. The varying volatility of these substances no doubt explains the fact, which has often been observed, that certain coals will coke in one type of oven where the heat is quickly applied throughout the mass, but will not yield a satisfactory product in ovens of a different kind. Dr. Muspratt* instances certain Staffordshire coals which, treated under ordinary conditions, give only brittle fritted coke, but which when subjected quickly to a stronger heat yield a hard product. In the five samples of non-coking coal used in these investigations a connexion seems to exist between the quantity of volatile matter at 300° Cent. and (1) the total hydrogen in the coal; (2) the total oxygen; (3) the disposable hydrogen; and (4) the ratio $\frac{\text{disposable hydrogen}}{1,000 \text{ carbon}}$ (see Table III.).

The volatile matter at 300° Cent. increases with an increase in the total hydrogen and in the amount of "disposable hydrogen," and conversely diminishes with an increase of oxygen. It also increases with increase in the value of the ratio $\frac{\text{disposable hydrogen}}{1,000 \text{ carbon}}$. Such a connexion does not exist in the case of the coking-coals, which affords additional evidence that in these minerals bodies of entirely different composition have to be reckoned with.

With reference to the oxidation of coking-coals, which it has been shown takes place very rapidly at temperatures as low as 140° Cent., this may in certain cases exercise an important influence upon the quality of the coke produced, for example, in bee-hive ovens, where, owing to the thickness of the charge and its low conductivity for heat, the coal in the centre remains in contact with the entangled air for a considerable time at a temperature below that necessary to produce coking of the mass. The writer has shown that exposure of finely ground coal to a temperature of 160° in a covered crucible, with only limited access of air, completely destroys any tendency towards coking in 1 to 1½ hours.

A general feature of coking-coals is the presence in them of only a small percentage of water when freshly mined, as may be seen from Table I. This characteristic appears to be due to the non-absorbent nature of the fusible constituent to which reference has been made, since

* *Chemistry*, third edition, 1876.

on oxidizing the coal the absorptive power is greatly increased. The following experiment will illustrate this:—A few grammes of Bannockburn Main coal, in pieces the size of beans, were immersed in a beaker of water for 15 days. The water absorbed amounted to 1·9 per cent. A similar sample was heated in air till it had gained 2·4 in weight, and was then immersed in a beaker of water alongside of the former. At the end of 15 days the water contained in the sample was found to be 6·7 per cent. The high content of water in Ell, Main and Virgin coals is probably to be ascribed to some similar process, since these three coals alone contain humus-like substances extractable with potash, and which can readily be formed in the others by atmospheric oxidation. It is also a fact worthy of note that, although the water content of the non-coking coals is already so high, it increases more rapidly in them (the Splint is an exception) than in the others. Thus samples of the above coals left in loosely-corked bottles, in the slightly damp atmosphere of the laboratory for one year, showed the following percentages (Table XX.) of water at the beginning and end of the period.

TABLE XX.—WATER CONTAINED IN COAL-SAMPLES.

Seams.	Hamilton District.					Kilsyth Haugh-rigg.	Bannockburn Main.	Kilsyth Coking.
	Ell.	Main.	Splint.	Gas.	Virgin.			
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
When freshly mined...	9·99	9·08	7·27	5·56	7·77	1·98	1·75	1·72
After one year in loosely-stoppered bottles (powdered)	*10·68	10·02	7·20	5·94	8·82	2·16	1·90	1·84
Increase ...	0·69	0·94	-0·07	0·38	1·05	0·18	0·15	0·12

* The question has sometimes been raised whether the loss in weight which coals undergo at 100° to 105° Cent. can be regarded as accurately representing the amount of water which they contain. Losses of 10·68 per cent. and 10·02 per cent., which are found to take place on heating Ell and Main coals respectively to 105° Cent., might well be suspected of having arisen from the expulsion of something more than absorbed water, seeing that such coals frequently come from perfectly dry pits, and are themselves to all appearance dry. It seems probable that a small part of the loss thus occasioned is frequently to be ascribed to the volatilization of organic matter. On the other hand, determinations of the loss which the above coals undergo, on standing for 48 hours over sulphuric acid at ordinary temperatures, gave 10·64 per cent. and 10·00 per cent. respectively.

The proportion of water contained in coals may thus be regarded as in some measure an index to the character of the samples, at least for the particular basin to which they belong. Connected, it may be, with this difference in the amount of water contained in coking and non-coking coals, is the peculiarity, which the writer believes holds not only for the Clyde basin, but for most, if not all, coal-areas, that in the non-coking varieties the cracks or "backs" are usually filled with a calcareous deposit, which is entirely absent in the strongly-coking seams.*

* An examination of this deposit proved that it consisted of practically pure calcium carbonate.

Upon the question of the constitution of coals, and the relationships between the constituents of substances so different in properties as the Lanarkshire Ell and Splint and the Bannockburn Main coals, it would be premature at this stage to venture a suggestion, even of possibilities.* One point, however, must be noted. If we compare the analyses of the coals in Table III. with those of the same coals, after being oxidized in air till they cease to gain in weight (Table XVI.), and these again with the figures for the acid bodies got by treatment of the coals with nitric acid (Table XVIII.), we are at once struck by certain outstanding facts. Thus, Ell and Main coals, though different at first, yield after atmospheric oxidation products of identical composition, but these are entirely different from the bodies got from all the others. The Splint and Gas coals, although found in seams not far removed from one another, do not show much tendency to approximate in composition when oxidized. Among the coking-coals, the original difference in composition between Bannockburn Main and Kilsyth Coking coals remains in part, even after the samples have been subjected to the above treatment; while Kilsyth Haughrigg gravitates towards the class represented by the Ell, Main and Virgin. Splint, on the other hand, shows a tendency to approximate in its composition to that of Bannockburn Main and Kilsyth Coking coals.

In the acid bodies which were prepared by acting on the Ell, Splint and Bannockburn Main coals with nitric acid, it is found that the former difference between the Ell and the other two still continues, but the products obtained from the Splint and Bannockburn Main coals are practically identical in composition.

What the precise significance of these observations is can only be ascertained by further investigation, and the writer is hopeful that in time it will be possible to adduce some further evidence on this part of the subject, on which he is still continuing his researches.

The CHAIRMAN (Mr. George Lewis) moved that the thanks of the members be accorded to the Reception Committee of the South Staffordshire and East Worcestershire Institute of Mining Engineers, to the authorities of Mason University College for the use of their rooms, and to the Cannock and Rugeley Colliery Company, the Earl of Shrewsbury and Talbot, the South Staffordshire Mines-drainage Com-

* Prof. Baltzer, *Vierteljahresschrift der Züricher Naturforschenden Gesellschaft*; and Dr. Muck, *Die Chemie der Steinkohle*, second edition, 1891, pages 140 and 141.

missioners, Messrs. Bumstead and Chandler, and Messrs. Thomas Parker, Limited, for having opened their collieries and works to the inspection of the members.

Mr. JAMES BARROWMAN (Hamilton) seconded the motion, which was heartily adopted.

Mr. J. L. HEDLEY (H.M. Inspector of Mines, Newcastle-upon-Tyne) moved that a vote of thanks be given to Mr. George Lewis for his services in the chair.

Mr. F. R. SIMPSON (Blaydon-upon-Tyne), seconded the motion, which was cordially approved.

The following notes record some of the features of interest seen by visitors to collieries and works, etc., which were, by kind permission of the owners, open for inspection during the course of the South Staffordshire meeting on September 13th, 14th and 15th, 1898 :—

CANNOCK AND RUGELEY COLLIERIES.

WIMBLEBURY MINE.

The seams worked include the Deep, Shallow and Six Feet coal-seams, suitable for household use and manufacturing purposes.

The shaft is 990 feet deep and 15 feet in diameter to the hanging-on. The iron headgear is 56 feet high, and the pulley-wheels are 14 feet in diameter. The winding-engine has two cylinders, each 32 inches in diameter by 5 feet stroke, and the drum is 14⅜ feet in diameter. The steam has a working pressure of 60 pounds per square inch. The steel cages raise four tubs at a time, each carrying 12½ cwts. of coal.

The hauling-engine, on the surface, has two cylinders, each 18 inches in diameter by 4 feet stroke, geared for endless rope, and working one compressor. The ropes are conveyed down the shaft, hauling 2,400 feet from the shaft-bottom, 1,350 feet of which rises at 5½ inches per yard. The coal from two districts is delivered on to this rope by a self-acting incline 1,950 feet long, with gradients varying from 4 to 8 inches per yard. Coal is brought out of the districts by main-and-tail rope. On the rise side of the shaft, the whole of the coal is lowered down by self-acting endless rope, the gradient being 9 inches per yard. The coal is delivered on to this rope from various inclines. The mines on this side rise at gradients varying from 8 to 28 inches per yard, and the face of the workings is 308 feet above the level of the pit-bottom. In the

Shallow coal-seam there is a compressed-air hauling-engine with two cylinders, each 12 inches in diameter. The main-and-tail rope is worked by a compressed-air engine. The coal is picked up by the first-named hauling-engine and conveyed to the shaft.

The screens for the Deep coal-seam comprize a main belt 164 feet long by 4½ feet wide, delivering into an elevator after the big coals have been taken off, then the remainder passes over a shaking-screen and is made into 3 or 4 qualities as required. The big coal of the Shallow seam is picked off the tubs, and the remainder passed over a shaking-screen and picking-belts, and made into 3 or 4 qualities as required.

The ventilation is produced by a Chandler fan, 10 feet in diameter and 5 feet wide, giving 51,000 cubic feet with 1·10 inches of water-gauge. It is driven by a horizontal engine, which also drives a dynamo of a capacity of 110 lamps of 16 candle-power.

The bull pumping-engine has a direct-acting cylinder, 20 inches in diameter by 5 feet stroke, and works a ram 7 inches in diameter.

Cannock Wood Mine.

The Shallow shaft is 534 feet deep, and 12 feet in diameter. The winding engine has two cylinders, each 24 inches in diameter by 4 feet stroke, fitted with a conical drum varying from 11 to 12 feet in diameter. Three tubs are drawn at a time.

An endless rope is worked by an electric motor of 60 horsepower, geared 32 to 1, by a belt 16 inches wide; the north-western district is 2,700 feet from the shaft; the office district, 5,100 feet from the shaft, and at a point 1,500 feet from the shaft, friction-gear works a rope into another small district; and the north-eastern district is 3,300 feet from the shaft. The south-eastern district, 5,700 feet from the shaft, is worked by main-and-tail rope, by an engine fixed on the surface.

The coal from the Six Feet seam is drawn at this landing, being lowered down by a self-acting incline. The coal is delivered to this rope by small engines from the various stations.

The most part of the coal in the Six Feet seam is wrought by coal-cutting machines, worked by electricity, and cutting 5¼ feet under, the average work per shift of 8 hours being 200 feet.

The Deep shaft is 600 feet deep, and 12 feet in diameter. The winding-engine has two cylinders, each 26 inches in diameter by 5 feet stroke, and drum 12 feet in diameter.

The haulage in the northern district, 6,000 feet long, is effected by endless-rope worked by a compressed-air engine. The north-eastern

district, 6,300 feet long, is worked by the main-and-tail-rope system, driven by an engine fixed on the surface. The south-eastern district, 5,700 feet long, is also worked by the main-and-tail-rope system, driven by an engine fixed on the surface.

There are 13 Lancashire boilers, 30 feet long and 8 feet in diameter, working at a pressure of 100 lbs. per square inch.

The Guibal fan erected in 1874 is 40 feet in diameter by 12 feet wide, and produces 227,000 cubic feet of air per minute, under 1¾ inches of water-gauge at 40 revolutions per minute. A 17 feet Chandler fan, to produce a similar quantity of air, is in course of erection.

Electric light is produced by a Brotherhood engine and Edison dynamo with a capacity of 400 lamps of 16 candle-power.

The Deep seam screens include a shaking-screen and picking-belts, for producing 4 qualities of coal. The Six Feet seam screens comprise a main belt 106 feet long by 5 feet wide, with elevator and shaking-screens, for producing 4 qualities of coal.

BRERETON AND HAYES COLLIERIES.

Hayes Colliery.

The No. 1 or Brick-kiln pit, working the Deep and Shallow seams, is 450 feet deep and 15 feet in diameter. The winding-engine has two cylinders, each 24 inches in diameter by 5 feet stroke, and a drum 10 feet in diameter.

The existing boilers are being replaced by four Lancashire boilers working at a pressure of 100 lbs. per square inch.

The No. 1 haulage-engine, on the surface, of semi-portable under-type, with boiler working at 80 lbs. per square inch, has two cylinders, each 12 inches in diameter. This engine works two drums on the head-and-tail-rope system, and hauls from four stations—No. 1, 2,640 feet; No. 2, 3,080 feet; No. 3, 4,820 feet; and No. 4, 4,750 feet in length respectively.

The No. 2 haulage-engine, on the surface, of semi-portable under-type, with boiler working at 65 lbs. per square inch, has two cylinders, 16 inches in diameter,. It works two drums on the head-and-tail-rope system, and hauls from two stations—the Deep, 6,140 feet, and the Shallow, 3,630 feet long respectively.

The No. 2 shaft is 450 feet deep and 9 feet in diameter. It is not used for drawing coal, but the No. 2 hauling-ropes pass down this shaft.

The ventilation-shaft, not used for drawing coal, is 450 feet deep, and

14 feet in diameter. The No. 1 hauling-ropes pass down this shaft. The Waddle fan, erected in 1887, is 30 feet in diameter, and it exhausts 78,000 cubic feet of air under 2½ inches of water-gauge, when running at 72 revolutions per minute.

There are three Lancashire boilers, each 30 feet long by 7 feet in diameter, and working at 60 lbs. per square inch.

The Deep coal screens comprize a picking-band, 108 feet long by 4½ feet wide, with narrow carrying-bands on each side 20 inches wide, a shaking-screen, four creepers and a tippler. The Shallow coal screens include a picking-band, 47 feet long by 4 feet wide, with a narrow carrying-band, on one side 2 feet wide; a shaking-screen, and 3 creepers.

Electric light, produced by a 300 lights machine, at 100 volts, driven from the fan-engine, is used for lighting the shops, bank, engine-houses, pit-bottom, stables, etc.

BRERETON COLLIERY.

The old engine or winding-shaft and the pumping-shaft are 540 feet deep and 9 feet in diameter. A condensing beam-engine, with a cylinder 36 inches in diameter by 6½ feet stroke, works a bucket-lift 9 inches in diameter by 6 feet stroke; and a ram, 11 inches in diameter and 6 feet stroke. There are two Lancashire boilers, each 30 feet long by 6½ feet in diameter, working at a pressure of 20 lbs. per square inch.

The Belfast pit, 360 feet deep and 9 feet in diameter, and the up-cast shaft for the Coppice pit is used for drawing water in case of emergency. The winding-engine has two cylinders, each 16 inches in diameter by 3 feet stroke, and the drum 7 feet in diameter, is fitted with a clutch-arrangement. There is one Lancashire boiler, 30 feet long by 7 feet in diameter, working at a pressure of 50 lbs. per square inch.

The Capell fan, 8 feet in diameter by 4¾ feet wide, running at 120 revolutions per minute, produces 25,000 cubic feet of air under ½ inch of water-gauge.

The pumping-shaft is 360 feet deep and 9 feet in diameter. The condensing beam pumping-engine has a cylinder 30 inches in diameter by 5 feet stroke, and works two lifts 12 inches in diameter and one lift 9 inches in diameter. There are two Lancashire boilers working at a pressure of 15 lbs. per square inch.

The Coppice pit working the Shallow seam is 300 feet deep and 9 feet in diameter. The winding-engine has two horizontal cylinders, each 16 inches in diameter by 3 feet stroke, and a drum 8 feet in diameter.

The No. 2 shaft is not used for drawing coal, and the hauling-ropes pass down this shaft. The hauling-engine has two horizontal cylinders,

each 14 inches in diameter by 2 feet stroke, and works two drums on the head-and-tail-rope system, the length of haulage being about 2,400 feet.

There are two Lancashire boilers working at a pressure of 50 lbs. per square inch.

The screens comprize a picking-band, 28 feet long by 4 feet wide, with a narrow carrying-band on each side, 12 inches wide; and a shaking-screen and creepers.

Electric light is produced by an Edison-Hopkinson dynamo, driven by a Brotherhood three-cylinder engine, and lights the offices, shops, Coppice pit, etc.

BRADLEY PUMPING-ENGINE.

The Davey pumping-engine at Bradley is the largest erected for the South Staffordshire Mines-drainage Commission, and one of the most powerful ever erected for the purpose of mine-drainage. The high-pressure cylinder is 52 inches in diameter, the low-pressure is 90 inches in diameter, and the stroke is 10 feet. The ram-pumps are 27 inches in diameter by 10 feet stroke. At each stroke, 496 gallons are raised from a depth of 380 feet. and at 7 strokes per minute the pumps raise 5,000,000 gallons of water in 24 hours.

In the Howl and Attwood compound direct-acting boiler feed-pump, the steam-chest is placed under the cylinder and contains a piston-valve which distributes the steam to the high- and low-pressure cylinder. The compounding effect is obtained by dividing the cylinder in the centre of its length and inserting a central division-ring of smaller diameter than the cylinder, through which a trunk works, and at the end of which are fitted two pistons of the full diameter of the cylinder. The annular spaces between the pistons and the central ring form the high-pressure areas, whilst the full diameter of the cylinder at the outer ends of the pistons forms the low-pressure areas. Steam is alternately conveyed to the high-pressure areas and thence to the low-pressure areas by the aid of the piston-valve, which is operated by live steam from the high-pressure areas without the aid of tappets or levers. The novelty of this pump lies in the small number of working parts and its self-draining facilities, as all the ports are placed on the lower side of the cylinder, and all condensation-water drains to the exhaust-ports by gravity. The pump is of the outside packed-ram type, fitted with outside valve-boxes, an arrangement which renders the pump-valves easy of access, and the whole forms an effective, strong, and compact machine.

CASTLE RINGS, CANNOCK CHASE.

BY W. H. DUIGNAN.

Castle Rings, the site of a so-called Roman camp, is not a camp, nor is it Roman. It is a British fort, made, probably, centuries before the Romans set foot in this country. The Romans did not construct forts of this character; but the natives did, and used them mainly as places of refuge, not of residence. There is no Roman road nearer than the Watling Street, 6 miles south, and the Romans had a stone-built and fortified city, Etocetum, now Wall, 7 miles south-east. In pre-historic times, the country for many miles round was a vast waste of woodland, heath and marsh, sparsely inhabited by a rude agricultural and pastoral race, divided into tribes. They were frequently engaged in tribal wars, and were exposed to plundering expeditions by their neighbours, much in the same way as the black races of Africa are at the present day. These forts were therefore necessary as places of security for themselves, their families, and their cattle; and we find them in all parts of England and the Continent, where people lived under similar circumstances.

The outside measurements of the entrenchment are 990 feet from north to south, and 1140 feet from east to west; the inside, from rampart to rampart, being 735 and 810 feet respectively. The area of the outside measurements is about 18, and of the inside, 14 acres. The elevation above the sea-level is 850 feet, and the fort commands an extensive view, embracing, it is said, nine counties. The ramparts are from 5 to 6 feet above the level of the inner enclosure. There are two ditches, or fosses, the inner one being about 18 feet in vertical depth, and the outside one about 9 feet.

Allowance, of course, must be made for the influence of storm and time and for the destructive hand of man during the last 2,000 years, at least. As our forefathers, who made these places, have left no written records, we have to trust to our imagination as to how they were constructed, and what implements they used; but the labour of digging these entrenchments must have been very great. It is probable that they had iron tools, for in the garden of the adjoining lodge, a large quantity

of iron has been smelted, on the spot; but whether in pre-historic, or later days, is doubtful. It was a common practice, centuries ago, to smelt lead or iron on hilltops, on account of the draught which their situation afforded. There is no ironstone here, and it must have been carried from the valley below, where it is exposed. The traces of these ancient furnaces or bloomeries exist on many parts of Cannock Chase. It was all charcoal-iron in those days, and the woods around were wasted, and in places utterly destroyed, to furnish fuel for the works.

In the park below, there are traces of ancient coal-mining, and the measures lying close to the surface have been got, all over that portion of the park, by means of bell-pits. These pits were at work 200 years ago, and some of them are far more ancient, as oaks, of centuries growth, are growing on their sides.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

GENERAL MEETING,

HELD IN UNIVERSITY COLLEGE, NOTTINGHAM, DECEMBER 3RD, 1898.

MR. W. D. HOLFORD, PRESIDENT, IN THE CHAIR.

The PRESIDENT (Mr. W. D. Holford) moved that a letter of condolence be written to Mrs. Wells, expressing the sorrow and regret of the members of the Institution at the great loss which she and the family have sustained by the death of Mr. W. E. Wells. He also moved that a letter, expressing their sympathy with Mr. Howard in his sufferings, be conveyed by his relative, Mr. Handley, together with the hope that he will be speedily restored to his usual health.

Mr. H. LEWIS (Annesley), in seconding the motions, said that he had known Mr. Howard from the commencement of the Institution. Mr. Wells had been a very useful man, and he was sure that his death was deeply regretted throughout the district with which he was associated.

The resolutions were unanimously adopted.

The election of the following gentlemen was announced :—

MEMBERS—

Mr. JOSEPH WILLIAM CUTTS, Colliery Manager, Blackwell Colliery, Alfreton.

Mr. HERBERT PILKINGTON, Ironworks Manager, Sheepbridge, Chesterfield.

ASSOCIATES—

Mr. HOWARD BLACKBURN, Under Manager, Birley Collieries, Sheffield.

Mr. HENRY D. GOULD, Under Manager, Birley Collieries, Sheffield.

Mr. WILLIAM RICHARDSON, Under Manager, Pleasley Colliery, Mansfield.

STUDENTS—

Mr. WILLIAM ROUTLEDGE, Mechanical Engineer, Broad Oaks Engineering Works, Chesterfield.

Mr. WILLIAM HAROLD BRAILSFORD, Mining Student, Blackwell Colliery, Alfreton.

The following paper by Mr. J. A. Longden on "Colliery-consumption" was taken as read :—

COLLIERY-CONSUMPTION.

By J. A. LONGDEN.

To the uninitiated the above seems no doubt a very vague title, but to the mining engineer it recalls one of those numerous standing charges which swell the cost of getting coal, and which managers seem almost helpless to control. Colliery-consumption means the quantity of coal used in generating steam for colliery use, and, therefore, does not include any allowance of coal to workmen. It is not proposed to deal with the question so much from the cost point of view, because at some collieries the coal consumed is not included in the weight dealt with in the cost-sheet, hence the cost of consumption does not appear as a separate item; at other collieries, the cost of boiler-fuel is taken at the nominal value of 1s. per ton: whilst at others, it is charged at its current market-value; and it is evident therefore that the cost per ton, even with the same consumption, may vary considerably. A few of the reasons why there is so much difference between one colliery and another in consumption per ton of coal drawn are:—Description and cleanliness of boiler used, setting and covering, temperature and chemical character of feed-water, size and quality of fuel consumed, method of stoking and fire-bars used, draught and proper admission of air both as to quantity and place, pressure of steam generated, and whether there is ample steam-space provided, or whether the boilers have to be heavily fired.

Then as to the engines, what a field of enquiry does this open! Simple direct-acting drop-valves are usually found applied to colliery-engines, but in overcoming the inclination to enlarge on that sentence the question of cut-off and compounding cannot be forgotten. When it is intended to work an upper coal-seam first and afterwards a deeper one, it is economical to put smaller cylinders on sufficiently large bed-plates to enable larger cylinders to be applied afterwards. The next item that presents itself to one's mind is the depth from which the coals are to be brought, and the weight to be drawn each time; this constitutes a far greater difference between one pit and another than casual

observers think. Then the number of journeys with men, dirt, water and timber, form a large and variable item, and many other points which have not been named suggest themselves to the mind of a practical colliery-manager.

As to the kind of boiler, the egg-ended or cylindrical is relegated to the past. Where, however, there is ample grate-surface and slow combustion, it is by no means a despicable servant and it is easily repaired. Recently two cylindrical boilers were driving two stone-breaker engines with hauling-gear attached, and consumed 65 tons of fuel per month: the experiment was made to force one cylindrical boiler to do the work, and the consumption increased to 75 tons per month. One of these boilers was taken out and a Lancashire boiler put down in its place to do the work of both egg-ended boilers, the consumption fell to 55 tons per month, and there was less smoke emitted, though the quality of the slack used was not so good.

From experiments it has been ascertained that soft scale in a boiler next to the fire $\frac{1}{8}$ inch thick wastes 10 per cent. of the fuel; if the scale be hard, the waste is considerably reduced, but the plates suffer. How many boiler-cleaners can, if they choose, say whether they have ever seen any scale more than $\frac{1}{4}$ inch thick on the tubes or shell of a Lancashire boiler? It is fortunate that when the scale is thick the heat often cracks it off, but when it is remembered that steam at a pressure of 90 lbs. per square inch means a temperature in the iron or steel-plate of 320° Fahr., and that with $\frac{1}{2}$ inch of scale that temperature must be increased to 700° Fahr., and that iron becomes granular and brittle at 600°, an element of danger is there, as well as waste.

The setting of boilers was dealt with by the present author before the Chesterfield and Midland Counties Institution of Engineers in 1876,* and the method then recommended, to place fire-clay guides under the boiler and space for the hot air to superheat the steam over the boiler, has been in operation at the Blackwell collieries ever since, with economical results and without any apparent drawback. This method, as it reduces the temperature of the gases leaving the boilers from 580° to 460° Fahr. and at the same time dries the steam, must be beneficial.

The economy between feeding boilers with water at 50° and 200° Fahr. is so palpable that there is no need to dwell on that item. As an illustration of the effect on the life of boilers of the difference of temperature, it may be mentioned that in several cases where Cornish

* *Transactions of the Chesterfield and Midland Counties Institution of Engineers*, vol. iv., page 173.

boilers were set with a single wall under the bottom and the heat passed down one side and returned up the other, the difference between the temperature on one side of the chimney-end of the boiler and the other was so great that constant fracture of plates was the result, until the boilers were set in the ordinary way, viz., heat to pass under the centre and up both sides.

Impurity in the water generally arises from the presence of carbonate and sulphate of lime, which it is difficult to prevent, and incrustation in the boiler is difficult to remove. Chipping boilers with sharp tools is most objectionable, and a hose-pipe with water under pressure removes much scale. Where the sediment is merely mud in the water, a pulsometer-filter has been found very beneficial. A colliery-manager recently stated that the boiler-composition which he was using to remove scale must be good, because if a drop fell onto a handkerchief it burnt a hole in it at once. The author's experience of the use of boiler-composition to prevent incrustation has not been very satisfactory, and he considers that it is much better to purify the water before admission.

The economical result of using good coal as compared with bad is self-evident, but, unfortunately, collieries have to use the fuel that they cannot sell. In the paper before mentioned, the author showed that the amount of water evaporated by 1 lb. of nut slack was 8½ lbs., but by 1 lb. of best coal 9½ lbs. of water was evaporated in a Lancashire boiler set in the ordinary way. If duff had been used, the weight of fuel used would probably have been 10 per cent. more for the same evaporation.

The next item is the method of stoking; and those who live in this neighbourhood and have read the columns of discussion appearing in the *Sheffield Daily Telegraph* on this subject a few years ago must feel that there is far more in it than at first sight appears. Whether the paper in question will benefit by the prosecution of its friends the proprietors must judge; but everybody is agreed that something ought to be done to remove smoke in our large towns. When the author took charge of the Stanton Iron-works Company's collieries about 10 years ago he thought that there was room for improvement in this matter, and made experiments first with fire-bars only, finally adopting the Caddy hollow fire-bar, and before doing so tried it carefully on three boilers where the whole energy developed was spent in driving a ventilating-fan, as this is the most regular work possible night and day. The result was satisfactory, viz., a saving of 20 per cent. in fuel and

very much less smoke, and these bars were adopted throughout at the 60 boilers at the various collieries belonging to this firm. The results, however, taken over a series of years, show that the consumption had not been reduced by nearly so much as 20 per cent. The consumption at Pleasley colliery used to be 6·4 per cent., and now is 5·3 per cent., but 12 Cornish boilers have been replaced by 12 Lancashire boilers. This change should help the economical working; but, on the other hand, the boilers are now able to consume dust taken out of the coal by the use of Proctor stokers. Formerly this dust was sold as slack to customers, and caused complaints and made the slack difficult to sell. This therefore reduces the economy from a comparative point of view. No doubt, with plenty of boiler-space, with gentle and careful firing, a man can generate as much steam and with as little smoke as any forced-draught apparatus or mechanical stoker yet invented; but where you wish to burn coke-breeze you require forced draught. All comparison of the useful effect of such inventions is useless, unless they are erected on the same boiler and the steam generated is utilized in a fan-engine over a long period, so as to determine the efficiency of the steam passing away from the boiler.

At this point, it may be stated that fine dust should be conveyed direct to the boilers to be used forthwith, and damped before using to prevent the flues from becoming choked. The hygrometric properties of samples of coal were tested from February 8th to March 15th, 1898, and 1 inch absorbed 3 per cent. of moisture, ½ inch 4 per cent., ¼ inch 5 per cent., and fine dust 7 per cent., which means great deterioration in value.

As to draught and proper admission of heated air, this resolves itself into a calculation, taking into account the area of grate-surface and the quantity of coal burnt. It has been clearly proved that too much air is really as bad as too little, from an economical point of view, and in the attempt to consume smoke more coal is often burnt than is needful. To maintain a good draught in the chimney, heat is necessary, and it is quite possible by using forced draught to spoil the chimney-draught and require live steam to make up for it. Unlimited air, undoubtedly, impairs the efficiency of the boiler. Some experiments made recently in America, show that to retard the air increases the volume of steam generated. Mr. Box in his *Practical Treatise on Heat*, shows that by forcing the firing and consuming twice as much coal as is theoretically needed the loss is 15 per cent.; by doubling the necessary quantity of air the loss is 23 per cent.; but by allowing the fire half the quantity

of air it should have, shows a loss of 52 per cent. These figures prove how necessary it is to have dampers within reach, and show that they should be constantly used.

We now come to a point on which there is at present no difference of opinion, viz., the economy to be obtained by increasing the pressure of the steam to say 120 lbs. on the square inch. Assuming that the boiler-pressure is 55 lbs. and that the engine has no cut-off (which is in a sense hardly possible, because the steam will automatically "wire-draw" itself), then the average pressure throughout the stroke will be 55 lbs.; but increase the pressure to 120 lbs. and then the cut-off will come into operation at 0·20 of the stroke to get an average pressure of 55 lbs., and considering that steam at 120 lbs. when cut-off at 0·20 of the stroke takes only half the fuel required when acting without expansion, the economy produced by raising the pressure from 55 to 120 lbs. is apparent. The use of the Guinotte or other efficient cut-off gear was fully described in Mr. Deacon's paper* and is equal to a saving of 20 per cent. when the pressure on the boiler remains constant. As to the loss through the piston being slack or the cylinder oval or not covered, or glands badly packed, it is impossible to calculate what that may be.

The comparative percentage-economies which may be effected under certain circumstances are :—Lancashire boilers *versus* egg-ended, 20; coated *versus* uncoated boilers and steam-pipes, 20; fire-clay guides under boiler and superheating of steam, 20; economiser and hot feed-water *versus* cold feed-water, 20; scale in boilers, 20; good coal *versus* inferior slack, 20; efficient stokers and proper admission of heated air, 20; high-pressure *versus* low-pressure steam, 20; good automatic cut-off, 20; and good pistons and engines in first-class condition, 20.

The natural conclusion to be derived from the foregoing remarks is that a dirty egg-ended boiler, uncovered, using cold water, driving a tumble-down engine, only produces 11 per cent. of the power which a modern plant, efficient in all particulars, would do for the same consumption of fuel. Every practical engineer, however, will admit that the various items, each of 20 per cent., are not overestimated, and might be increased in number.

The facts which originated this paper were a comparison of the colliery-consumption at various pits with which the author is connected, as follows :—

* *Trans. Inst. M.E.*, vol. vii., page 672.

Colliery.		Annual Output. Tons.		Coal Consumed. Tons.		Per Cent.		Depth of Pits. Feet.
No. 1	...	200,000	...	6,400	...	3·2	...	390
No. 2	...	300,000	...	9,000	...	3·0	...	630
No. 3	...	200,000	...	7,000	...	3·5	...	780
No. 4	...	200,000	...	10,000	...	5·0	...	450
No. 5	...	100,000	...	10,000	...	10·0	...	480
No. 6	...	300,000	...	22,500	...	7·5	...	600
No. 7	...	400,000	..	21,200	...	5·3	...	1,500
No. 8	...	150,000	...	10,500	...	7·0	...	1,200
Totals	...	1,850,000	...	96,600	...	5·2	...	—

These collieries are situated in Yorkshire, Derbyshire and Nottinghamshire, and each produces coal from different depths and under varying conditions. The author now proposes to reduce these circumstances to a common denominator, so as to arrive at some basis which may be considered as a fair average for colliery-consumption.

An average of 270 days is worked at a colliery in this district, and the pit winds coal and men only for 9 hours, or 2,430 hours per annum, whilst the year contains 8,760 hours, or nearly four times as many, so that the number of hours the pit is actually winding coal is a very important factor.

It is too intricate a matter to ascertain the number and size of each engine at the eight collieries, consequently a general basis must be adopted. Assuming that at each of the collieries, the usual underground haulage arrangements prevail, that except (when specially mentioned) there is no large amount of water to be pumped, and that a fan produces the ventilation in every case; as a matter of fact these conditions are the same and the collieries are of about the same age, and the coal-face is about the same distance from the shaft-bottom. The first three collieries may be considered to be equal, and in each of these there is very little dirt drawn and very little night work. At No. 1 pit, there is a small pump, which, working at night, accounts for the high consumption, looking at the difference in depth. At No. 4 pit, the steam is generated by gas made in producers, otherwise it certainly ought not to be much more than half what it is. The conclusion must, therefore, be arrived at, that if a colliery had to be worked entirely by gas-producers, the colliery-consumption would be double what it is at the present time, and this is, therefore, a very expensive method of consuming smoke. No. 5 pit is one of the most heavily-watered pits in the Midland counties, raising 30,000 gallons per hour from the full depth of the shaft, and this accounts for a very high consumption. No. 6 pit is also a heavily-watered colliery, 15,000 gallons being pumped per hour; it has, in addition, the whole of its coal-face on the dip, and none of it is less

than 1 mile from the pit-bottom. Recently at this colliery, the waste-gases have been conveyed from 40 coke-ovens, and have reduced the colliery-consumption from 7½ to 6 per cent., which is a clear proof that the boilers were far too heavily fired before. No. 7 pit is Pleasley colliery, which has been referred to in this paper, and where the consumption has been considerably reduced already, but it is not as low as it would be if there were not two winding-engines constantly running for the quantity named. The same remark applies to No. 8 pit, where two winding-engines are doing no more than one ought to do, as it is a comparatively new pit drawing a large quantity of dirt; on the other hand, with a modern plant, pit nearly 1,200 feet deep, steam-pressure at 100 lbs., raising 12,000 tons per week, and having mechanical stokers and economizers, the consumption is 2¾ per cent., and this probably is a minimum for the depth, the working-faces being near the pit-bottom.

A few illustrations of foreign experience are as follows:—The proportion of the output of anthracite-mines which is consumed in doing the work required in mining has been a subject of much discussion, the *Engineering and Mining Journal* (New York, U.S.A.) thinks that 7 per cent. is under rather than over the mark: thus, careful records kept at the Girard Estate collieries show that in 1895 of an output of 1,685,652 tons, 13·2 per cent. was used at the mines, whilst in 1896 of a production of 1,469,837 tons, 15·6 per cent. was so used, the proportion being naturally higher on a smaller output. Again, at the mines of the Lehigh Coal Company, in 1896 of a total of 1,549,098 tons, 9·6 per cent. was used, and in 1897 the proportion was 7·9 per cent. on a total of 1,530,823 tons, here the reduced proportion was the result of a number of economies introduced. At the Ewald pit, in Westphalia, which is about 1,800 feet deep, and where 2,334 horsepower is in use for all purposes, a most elaborate condensing plant has been erected at a cost of £4,000, the net result being that whereas with compound engines the colliery-consumption was 5·32 per cent., now with compound and condensing engines it is 4·38 per cent. of the total production of the colliery.

Mr. C. M. Percy recently stated at a meeting of the Manchester Association of Engineers, that he considered the average consumption to be not less than 5 per cent. taking 1,800 feet as the depth of the mine; and this shows that the consumption of coal at collieries is 10 times as great as it is in a good modern mill-engine. The average depth over the whole kingdom is, however, much nearer 1,200 than 1,800 feet, therefore the loss should be much more than what he states; but his

statement that 5 per cent. is consumed where the depth is 1,800 feet agrees very closely with the results obtained from various collieries in the Midland counties where there is no pumping or dirt-drawing.

As an illustration of economical working, Mr. Edmund Howle, the general manager for the South Staffordshire Mines Drainage Commissioners, informed the writer that the Moat pumping-engine, which develops 236 horsepower, used last year 6,000 tons of slack of a value of 2s. 9d. per ton delivered, and lifted 662,000,000 gallons of water to a height of 620 feet; and this shows that each horsepower required 6·6 lbs. of coal per hour.

Prof. Galloway, in his paper on coal-mining, estimated that in a Worthington pump with a triple-expansion and condensing engine lifting 400 gallons of water per minute to a height of 800 feet in one lift, each pump horsepower required 7·0 lbs. of coal per hour. The Worthington Pumping-engine Company state that 1,000,000 foot-pounds can be developed from 1 lb. of coal, or equivalent to 2 lbs. of coal per hour for each pump horsepower, but this is no doubt without reckoning pipe-friction.

When we turn to the intermittent work of winding-engines, Prof. Galloway reckons that 700 tons per day from a depth of 792 feet require 3 tons of coal, which is the equivalent of 10·7 lbs. of coal consumed per hour per horsepower; but unfortunately as much more coal is required to draw men and timber and keep up steam day and night, the actual coal consumed is 21·4 lbs. per hour per horsepower.

When we remember that 1 lb. of coal should generate enough heat to maintain 5 horsepower for 1 hour, the comparison between the theoretical result and actual practice is very unsatisfactory. An efficient engine develops 1 indicated horsepower with 2 lbs. of coal, or say 1 nominal horsepower with 3 lbs. of coal, but H.M. Commissioners found as a result of exhaustive experiments that 11 lbs. of small coal was required to develop 1 horsepower. It has been ascertained that 1 lb. of Derbyshire or Lancashire coal should evaporate 14 lbs. of water at 212° Fahr. into steam, best South Yorkshire 14½ lbs., and Newcastle or Welsh coal about 15 lbs.

Authentic trials having shown an efficiency of 80 per cent., if we assume 14 lbs. as the evaporating power, then the working result should be, when all the conditions are favourable, 11·20 lbs., or with best coal 12 lbs. of water evaporated per 1 lb. of coal; but, unfortunately, there are far more cases where the efficiency is 60 than 80 per cent., and this reduces the evaporation to 8·4 lbs. for Derbyshire and Lancashire coal; and to 9 lbs. for Newcastle and South Wales coal.

The loss of 40 per cent. of heat is accounted for by Mr. D. Phillips in his book on *Fuels* as follows :—

	Per Cent.
Unregenerated in the combustible gases	5·5
Lost in clinkers and ash	1·5
Carried off in gaseous products of combustion	5·5
Unregenerated in the smoke-carbon	0·5
Absorbed in the smoke-carbon of the hygrometric water and water newly formed	2·5
Lost in the brickwork	23·5
Total	39·0

Twelve lbs. of air is necessary to burn 1 lb. of coal ; but as the volatile portion of the coal is consumed before the fixed carbon, and the volatile gases require a greater volume of air than the fixed carbon, the time in which each of these is consumed must be taken into account. Hence the usual rule is 24 lbs. of air per 1 lb. of coal, and as 12·387 cubic feet of air is equivalent to 1 lb., the quantity of air usually considered necessary to consume 1 lb. of coal is 300 cubic feet. There is no doubt, however, that this large quantity of air causes loss of heat. The endeavour to prevent smoke, unless carefully watched, becomes mere waste, as the excess of air carries off heat and to obtain the necessary power more coal has to be consumed.

The advantage of frequent stoking and in small quantities is evident, and in this, mechanical stokers have undoubtedly the preference. In a paper recently read before the American Society of Mechanical Engineers, Mr. J. M. William gave the following general summary of tests of three types of mechanical stokers :—

1. Stoker-engines use from 0·20 to 0·40 per cent. of the steam generated.

2. Fan-blast use from 3 to 5 per cent. of the steam generated.

3. Steam-blast use from 5 to 11 per cent of the steam generated.

4. Each of the stokers allow too scanty air-space in the grate.

5. None of the three stokers will raise as much steam as hand-firing, with stationary grates having the same draught and coal conditions.

6. The self-cleansing stoked fire is, however, always in the same condition as a hand-worked fire after cleaning.

The pounds of water evaporated per pound of coal given in the author's paper in 1876, seem to be excessive compared with recent results, but the relative proportion would no doubt be correct. At Silverhill colliery, a boiler 30 feet long and 8 feet in diameter, with two tubes 3¼ feet in diameter, maintained steam at a pressure of 76 lbs. per square inch for 5½ hours, burnt 9,072 lbs. of coal, and drove a Capell fan

12½ feet in diameter and 11½ feet wide with double inlets 7½ feet in diameter, at a speed of 38 revolutions per minute; producing a ventilating current in the mine of 106,037 cubic feet per minute, at a water-gauge of 2·45 inches or 40·93 horsepower in the air. If we assume 50 per cent. of useful effect in the steam, that means 81·86 indicated horsepower in the engine, produced by 28 lbs of slack consumed per minute, whilst 6½ lbs. of water was consumed per 1 lb. of coal on this occasion. Yet the average of many experiments at different collieries and with the apparatus of numerous makers is about 5 lbs.

The old rule to find the horsepower of a boiler was based on an evaporation of 1 cubic foot or 62½ lbs. of water evaporated per hour, but with efficient engines, boilers are now developing 1 horsepower with 20 lbs. of water, and triple-expansion engines with as little as 15 lbs. In another test at Silverhill colliery, 5,055 gallons of water were evaporated in 5½ hours or 918 gallons per hour: as the fan-engine indicated 81·86 horsepower, this shows that the number of gallons evaporated per effective horsepower was 11·21: and as this steam was generated by forced draught there must be a slight deduction for the four nozzles ($\frac{3}{16}$ inch in diameter) which produced the forced draught. This boiler is set with fire-clay guides underneath, and there is a super-heating-chamber on the top. It is curious to read that French railway-locomotives consume 50 lbs. of water per horsepower per hour.

Colliery-consumption does not occupy that place in the mind of mining-engineers that it should do. When the cost-sheet deals with the sale-tons only, then it does not appear in any form whatever; and when the item is charged at say 1s. per ton in the cost-sheet, the amount, probably less than 1d. per ton in the total cost, does not call for much attention; but when the average selling-price is got out firstly on the sales only, and afterwards on the total sales or produce, including colliery-consumption, some managers may be surprised to find that 1d. per ton on the face of the cost-sheet actually reduces the total average selling-price by 4d. per ton. And in these days many colliery-owners would be pleased to see a profit of 4d. per ton on the total result of their working, without allowing anything for replacement of, or interest on, the capital employed. And when we consider the enormous quantity of coal which we use as a nation per head of population, as compared with other nations, it behoves us to take greater care of one of the secrets of England's greatness. The yearly consumption of coal per head of population in Great Britain is 3·75 tons; Belgium, 2·56 tons; Canada, 1·16 tons; New South Wales, 1·25 tons; and France, 0·95 tons.

We may roughly assume, for a 9 hours' day of winding coal where there is no water-pumping or dirt-winding, that the consumption should be 1 per cent. for each 300 feet that the pit is deep, at a colliery which has been in operation 20 years. A new colliery using high-pressure steam and more modern appliances will undoubtedly consume less coal than 1 per cent. for each 300 feet in depth.

Mr. H. R. Hewitt read the following paper on "An Improved Ambulance-carriage and Stretcher for Use in Mines":—

AN IMPROVED AMBULANCE-CARRIAGE AND STRETCHER FOR USE IN MINES.

By H. RICHARDSON HEWITT, H.M. Inspector of Mines.

A desire to alleviate the sufferings of his fellow-men is the writer's only apology for bringing to the notice of members a new arrangement for conveying injured workmen employed in the mine, direct from their working-place to the bed at the hospital or at home, with a minimum amount of the suffering necessarily attending the removal of such cases. With the use of this carriage and stretcher, an injured person can be

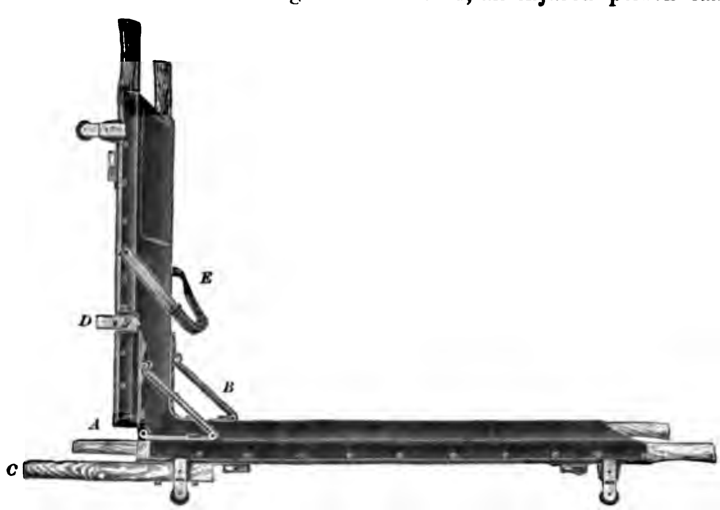


Fig. 1.

placed upon it in any part of the mine where a tub can run, conveyed to the pit-bottom, taken up the shaft (even if the shaft be a narrow one), placed in a conveyance, carried upstairs upon reaching the hospital or his own home, and placed upon a bed without having once left the stretcher, or without having been subject to any exertion on his own part, and with a minimum amount of trouble to those who are attending him. The writer regrets being forced to the conclusion that injuries are often aggravated by the sufferer being conveyed up a narrow shaft in a pit-tub, and by his being carried up an ordinary cottage staircase, which is sometimes steep, frequently broad enough for only one person, and not always strongly made.

The stretcher itself is much the same as the old pattern, but to gain an inclined position the longitudinal bearers are provided with hinged joints, *A*, at a convenient distance from one end, so as to allow of that end being raised into any position to suit the requirements of the case or the comfort of the sufferer, and to enable the stretcher to be drawn through a narrow shaft or carried up a staircase. Adjustable stays, *B*, are provided, by which the desired inclined or vertical position of the raised end may be varied and secured. Two supplementary handles, *C*, are provided for convenience of carrying when the stretcher is not in an horizontal position, and these are utilized for securing the hinged part of the stretcher when it is horizontal, in this way strengthening the frame also. The iron clips, *D*, make this horizontal position doubly secure. A suitable strap, *E*, is provided for securing the injured person

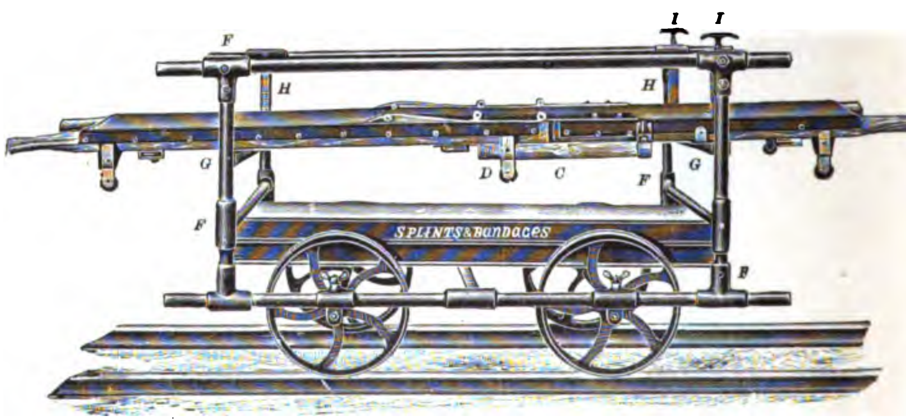


FIG. 2.

in any position on the stretcher, while being conveyed from the mine or up the shaft. This stretcher may be used for drill and general ambulance purposes, or in conjunction with an ambulance-carriage. Its length is 7 feet, with canvas 6 feet long, width 1¾ feet, and it weighs complete 35 pounds.

The ambulance-carriage consists of light longitudinal and transverse bars of turned ash, which are secured to each other by means of the malleable-iron tee-sockets *F*, and riveted. It is provided with flanged wheels to correspond with the underground roads upon which it is to travel, and collars and set-screws are provided on the axles, so that the gauge may be varied and altered to anything up to 32 inches, and thus it can be used on any of the underground roads of the mines of this district. In mines where a wider gauge of rails is used, the carriage itself would have to be made of a larger size. From the upper longitudinal bars of

the carriage are suspended two transverse bearers, *G*, upon which the stretcher is laid; and the connexions between these bearers and the longitudinal bars are made by four spiral springs, *H*, so that the injured person may be conveyed without unnecessary movement or jolting. At one end of the carriage are provided movable stays, *I*, which enable the stretcher to be secured in a horizontal position when riding up or down steep inclines in the mine; these iron stays slide up and down in suitable sockets, and are secured in position by means of thumbscrews. The wheels and axles may be detached from the carriage by unscrewing the thumbscrews, and the stretcher and carriage can then be placed in a cart or light conveyance to take an injured person to the hospital, or to his own home. On the carriage is provided a box or drawer, containing tourniquet, splints, bandages, etc.; the splints are fitted with zinc sockets, so that their length can be adjusted within reasonable limits. The length of the carriage is 4½ feet, width 34 inches, height on wheels 28 inches, height without wheels 18 inches; the weight of the carriage complete is 102 pounds, and the total weight of carriage and stretcher is 137 pounds.

The ambulance-carriage and stretcher are the invention of Mr. William Hallam, who is the local superintendent (at Eckington, near Sheffield) of the St. John's Ambulance Association.

The writer's criticism only leads him so far as to suggest that the carriage-wheels should be fitted with springs, and thus make the running still more comfortable to the person riding. He fails to see the necessity of providing the axles with collars and set-screws to regulate the wheels to certain gauges of road: these collars and set-screws are a source of weakness, and the wheels should be fixed to the axle to any gauge ordered.

Mr. A. S. DOUGLAS (Hucknall Torkard) said that the only point that struck him was as to the carriage which, though apparently an exceedingly good one, would not in many mines be suitable, especially in collieries where endless ropes were used. He did not see in such cases how the carriage could conveniently be used, and he was afraid that in the majority of cases the old method of carrying out the men by hand with as little jolting as possible would have to continue. He was afraid, too, that in practice it would be found impossible to carry an injured man upstairs and lay him upon his bed, without removing him from the stretcher. The majority of existing staircases would have to be made wider, and without the abrupt turns with which they were at present constructed. He did not wish to minimize the value of the arrangement,

but he was afraid that the inventor would be disappointed if they desired to see it introduced into every colliery.

Mr. G. Lewis admitted that the arrangement was a very admirable one, and if they were using it in the streets of Nottingham they would get along very comfortably, but underground they had a different state of things. Many of the collieries had extensive systems of endless-rope haulage, with double roads, and he did not see how such machines were to be used. He had made up his mind to recommend its introduction, but on further consideration he did not see that it would be of any value in any of the collieries with which he was connected. At present, there was no better way of conveying an injured man to the pit-bottom than carrying him in an ordinary St. John's ambulance-stretcher.

Mr. A. H. Stokes hoped that there would be one at every colliery, or something like it. There was of course a difficulty on endless-rope roads.

Mr. C. Latham asked whether such an arrangement would be in accordance with the Special Rule forbidding men to ride up an incline with loaded tubs?

Mr. A. H. Stokes replied that in case of injury to workmen or safety of life he had never yet stood at a Special Rule, and it was too late for him to begin.

Mr. M. H. Mills said that if a man were seriously injured in a low seam it was very difficult to get him out, and he thought that the arrangement described by Mr. Hewitt would be particularly applicable in such cases.

The President (Mr. W. D. Holford) said it occurred to him that the stretcher was the most useful part of the machine, and if it could be attached by its springs to an ordinary pit-tub which had the ends knocked out, it would be most convenient and handy; and by having a number of stretchers in various parts of the pit they would be readily available.

Mr. G. J. Binns said that an injured man had often to go through sidings which were full, or down gate-roads where tubs were standing, and there was nothing more common than to lift the man in the ambulance over the tubs instead of delaying to get the whole road clear for perhaps a mile. To convey the arrangement exhibited to the members—admirable as it was—from the face to the pit-bottom would often prove a very difficult problem.

Mr. J. MEIN (South Normanton) observed that there were few colliers who would quietly wait with an injured man until the carriage could be brought. They would say, "we are going to have this man out," and in nine cases out of ten he would be at the pit-bottom before the conveyance could reach him.

Mr. A. H. STOKES remarked that if engineers would place the workings in telephonic communication with the pit-bottom and the surface, the possibility was that the ambulance-carriage would be at the place before they had got the man liberated. At some mines they went a little further, and doctors were sent down the pit and attended to the injured man before he came out.

Mr. H. R. HEWITT (Derby), replying to the discussion, said that it was desirable that some appliance of this kind should be kept at every mine, and this was the best that he had seen up to the present time. The carriage could be used, where the rope was over the tubs, by placing it between two tubs which would carry the rope above the man lying on the stretcher. He could not understand the objection of Mr. Douglas as to carrying the injured person up a narrow staircase, as the handles of the stretcher were in such positions that this could be easily done by two men, and the injured man would have his body in a vertical position strapped to the stretcher. He thought that it could be carried round the sharpest turn to be found in a cottage-staircase. The stretcher and carriage were in use at the Eckington collieries where the endless-rope was principally used for moving the tubs, and no difficulty had been experienced such as that suggested by several members. Ropes usually travelled at 2 or 3 miles per hour, and this was as great a speed as men would go when carrying an injured man on the ordinary stretcher. In many mines, electric signals and telephones are used, and where the telephone is not in operation a special signal is used when the stretcher is required. Even where the ordinary stretcher is used, the men carrying it frequently meet the injured man being brought out in a pit-tub, when they transfer him to the better conveyance. One able-bodied man would bring this carriage and its load to the pit-bottom, whereas it required several changes of men to carry an injured person upon an ordinary stretcher the same distance, more especially if he be conveyed through roads where it is impossible for the bearers to stand or walk upright.

The PRESIDENT moved, and Mr. A. S. DOUGLAS seconded, a vote of thanks to Mr. Hewitt for his interesting paper.

DISCUSSION UPON MR. G. BLAKE WALKER'S PAPER ON "THE EDUCATION OF MINING ENGINEERS"* AND PROF. HENRY LOUIS' PAPER ON "TECHNICAL EDUCATION IN MINING."†

Mr. C. LATHAM remarked that Mr. Blake Walker started with "Our present system and what we should aim at"; and he entirely agreed with what Mr. Walker had said. He went on to deal with "Our present educational facilities," and said that he would confine himself to the facilities which might be made use of by students in the Midland district. The first that he mentioned was the Royal School of Mines in London. Then he went to the extreme north of England, and referred to the Durham College of Science, Newcastle-upon-Tyne. A little nearer the Midlands were the Yorkshire College at Leeds and Firth College, Sheffield; but University College, Nottingham, he left out in the cold altogether. He should like to remind Mr. Blake Walker that there was such a place, and that they had there a mining course. And was there not another institution which he had omitted—the Wigan School of Mines—although that had probably turned out more brilliant men than any school in the country? These institutions might be insignificant from Mr. Blake Walker's point of view, but their real significance was very great indeed. He might mention that a student of University College, Nottingham, had that year won the prize offered to student members of the Institution (and open to all the world) for the best essay on "Coal-cutting by Machinery."‡

Mr. G. E. COKE said that the value of the paper was not so much in matters of detail as in the general principles discussed. The chief enemy of Prof. Louis was the Mines Regulation Act. He objected to the form in which the certificate of a manager had to be obtained, and considered that it was detrimental to their system of education. Whether that were so or not, he did not consider that the fact of having to serve for 5 years in a mine prevented anyone with sufficient energy and opportunity from getting a very good theoretical education as well. If a man received a liberal education he could get his practical experience, and continue improving his mind, even very much later in life. If any alterations were made, he would suggest that if a practical certificate were taken for either the manager's or under-manager's certificate, and a certificate on more theoretical subjects for the higher grade, it would meet the case.

* *Trans. Inst. M.E.*, vol. xii., pages 132 and 213. † *Ibid.*, vol. xv., page 5.
‡ *Ibid.*, vol. xvi., page 67.

Mr. G. J. Binns thought that the subject divided itself into two portions—the education of mining-engineers, and technical education in mining generally. The number of colliery-managers constantly being trained in Great Britain was large, and many of them found it advisable to go abroad. He had recently had two young students, one of whom was now at Klondyke and the other in South Africa. There were schools of mines scattered all over the world, giving an excellent education; but all of them did not turn out every day men competent to take up appointments as metallurgists and assay-managers. Neither of the papers—which were very elaborate and interesting—discriminated sufficiently between whether a man wished to be a colliery-manager, or whether he wished to go into the world and fight his battle with men from other schools where such matters were taught. It was difficult for a man in a short space of time to perfect himself both in coal and metalliferous mining, but if he had a grounding in general science—especially geology and chemistry—he could make a fair start, and obtain sufficient knowledge to get a position. Prof. Louis advocated * that "certificates should be granted upon examinations controlled by a central board, making the examination identical in conditions and character for the whole of Great Britain." He (Mr. Binns) had the privilege of pressing that view upon the notice of Mr. Asquith when the latter was Home Secretary. He believed that the age now was made uniform, but when he had the misfortune to sit it was 21 in one part of the country and 23 in another. At any rate, even now the conditions of examination vary considerably, and candidates flock to one place while they carefully avoid another.

Mr. A. H. Stokes had seen a large number of students attending the mining classes, and could state that the work done by the County Council lecturers was of great value. There were working-men who could beat some of the articled mining-pupils. In his opinion, the County Councils were doing really valuable work with the money which they were spending on technical education in mining.

Mr. C. Latham said that Prof. Louis remarked † that when a young man left the Board School he should be "in the sixth, or at lowest the fifth standard, with the rudiments of a sound education, a knowledge of English grammar, history, etc., a decent handwriting, and a knowledge of arithmetic, going, say, but little beyond decimals." This was quite true, but it was not his experience to find it so in practice. The County

* *Trans. Inst. M.E.*, vol. xv., page 18. † *Ibid.*, vol. xv., page 5.

Councils were doing an exceedingly good work, but if they did not like the Science and Art examinations, why take them? It was the fault of the County Councils. In the Midland district, they had their own examination, and Mr. Stokes had been good enough to undertake the duties of examiner. If the other counties would induce H.M. inspectors of mines to take the same interest in the work as Mr. Stokes did greater success would attend their efforts.

Mr. J. H. W. Laverick recommended that a student should take his technical and practical training together as far as possible. If he intended to be a practical colliery-manager let him devote himself principally to practical work, because when he became a manager he would have to deal with practical men. One of the most important points about colliery-management was dealing with the men, and that was one of the principal arts of colliery-management. He would urge every student of mining to devote himself to the practical side to the utmost of his ability, and to do in a thorough manner all the work which miners and subordinate officials had to perform. It was very important that the Central Examination Board, however it was formed, should consist of one or more examiners out of every district, and he hoped that, if Prof. Louis' proposal were adopted, the members of their Institution would see that their district was properly represented on the Board.

Mr. M. H. Mills said he had always felt that one branch was very much neglected in the education of mining-engineers, and that was the mechanical part. In his own training, he had few opportunities of obtaining a knowledge of machinery, and he was afraid that the subject was not sufficiently considered by the colleges. It appeared to him that a man to become a really good mining-engineer—especially if he had any prospect of going abroad—should at least spend one year at some large repairing-shops. Another branch which was neglected was that of languages.

Mr. H. R. Hewitt said that a perusal of these papers led him to think that the writers were of opinion that present-day mining-engineers were not capable of performing their duties, as they have not had a sufficiently scientific education in their earlier days. In his opinion, they had greatly overdrawn the case, and if all their suggestions were carried out they would leave a man in a poor state. The age of 25 was generally quite low enough for a manager or under-manager to take charge, but he knew of a case where a man of 21 was appointed manager

of a mine drawing 400 tons of coal per day, and where there were great water difficulties to be contended with, and he carried out his duties successfully. There was at the present time an under-manager of a mine drawing 1,200 tons of coal per day who was only 23½ years old; but he should add that a certificated manager spent the whole of his time at this mine. These were, of course, exceptions to the general rule; but he was a great believer in giving young men some responsibility as soon as they personally showed themselves capable of fulfilling it. Youth was a fault which would remedy itself; but, as a rule, the age of 25 was young enough for men to have the charge of the lives and capital in and about their coal-mines. The suggestion of an examination for surveyors was a good one, and would probably be an accomplished fact in a few years' time. It was necessary that colliery-plans should be kept by persons of the highest qualifications, and in some cases there was at present room for improvement in this direction. "The owner, agent or manager" was now responsible for this work, and in some cases he neither made the surveys nor did he check their accuracy. If the manager did the work there would not be so much fault to be found with the absence of return-airways on some plans, which some surveyors appeared to think were quite unnecessary in a mine. He agreed with Prof. Louis when he suggested that coal-mining experience should count as part experience in metal-mining; but he disagreed with him when he stated that experience gained in metalliferous mines should go for experience as a colliery-manager, especially as he was at some trouble to point out that metal-mining in this country was still carried on in the same way that it was 100 years ago and improvements were making but slow progress. The two branches of mining-engineering were distinct, not so much in their engineering problems as in their practical work. In coal-mines, we are not constantly analysing the chemical constituents of the seam, but in metal-mines this is a very important branch, especially when lead-ore may contain anything besides lead; and in the same vein it is a common thing to find that the lead-ore contains silver in various quantities from *nil* to 5,000 ounces per ton. The necessity of a college course was emphasized too strongly in both papers, and, in his opinion, it was necessary to give the prospective mining-engineer a sound education on the modern side of a public school until he was 18 years old, as suggested by Mr. Walker. Beyond this, to make a special study of mathematics, not because of the great mathematical problems which he would be called upon to perform, but because a mathematically-trained mind could always grasp every subject in such a broad-and-

far-seeing way that it would overcome difficulties while a mind not so trained was still thinking about the matter. Given also a varied experience in all classes of coal-mining work in various coal-fields, and the intelligent perusal of the best of the modern text books, a man should be capable, at the age of 25, of anything that he was called upon to perform. If all the suggestions in the papers were carried out, a man would be 40 years old before he was any good as a mining-engineer, necessarily a man of private means, and not inclined to pursue the matter further, as he would then consider the responsibilities too great, and would not feel inclined to be at the beck and call of a board of directors or a colliery-owner.

Prof. H. Louis (Newcastle-upon-Tyne) wrote that he was gratified to find that his paper had been considered worthy, in conjunction with Mr. Blake Walker's valuable address, of the careful discussion that it had received at the hands of the members of the Chesterfield and Midland Counties Institution of Engineers. He did not think that he could add much more to what had already been said, but he would like to point out that Mr. H. R. Hewitt had certainly misinterpreted his views. He never either thought or suggested that "present-day mining-engineers were not capable of performing their duties"; what he did hold was that a certain number of mining-engineers would perform their duties better if they had had a more scientific education. It must also be borne in mind that scientific methods were coming into everyday use in mining to an extent undreamt of 25 years ago. There were not a few working miners, for example, who had a far more distinct notion of what was meant by such scientific terms as "ohms" and "ampères" than was possessed by even the well-trained mining-engineer of a couple of generations back. He was quite prepared to find wide differences of opinion on all questions of detail, but was glad to see the strong feeling growing up that the present system of education did admit of great improvements in various directions. It was also satisfactory, though scarcely surprising, to see that the present system of examination for colliery-managers' certificates, with the wide variation between the conditions of examination, and even of minimum age limit, between different districts, had not found a solitary defender. He hoped that such strongly expressed and practically unanimous opinion would have the weight it deserved to have with the Home Secretary, and would induce a speedy revision of the regulations.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, FEBRUARY 11TH, 1899.

MR. WILLIAM COCHRANE, PAST-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on January 28th and that day.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. WILLIAM LAWTON GOODWIN, Director of the School of Mining, Kingston, and Professor of Chemistry, School of Mining, Kingston, Ontario, Canada.

Mr. N. MAURICE GRIFFITH, Mining Engineer and Colliery Manager, Broughton and Plas Power Coal Company, Limited, Wrexham.

Mr. JAMES RADCLIFFE, Consulting and Manufacturing Engineer, 124, Victoria Street, Westminster, London, S.W.

Mr. EDWARD CHARLTON SCOTT, Mining Engineer, 20, Henrietta Street, Swansea.

Mr. HENRY LIVINGSTONE SULMAN, Metallurgical Chemist, 60, Gracechurch Street, London, E.C.

Mr. FRANCIS SYMONS, Mining Engineer, Ulverston, Lancashire.

Mr. RICHARD THOMAS, Colliery Manager, Brown's Duckenfield Collieries, Minmi, Newcastle, New South Wales.

ASSOCIATE MEMBER—

Mr. JOHN THOMAS LUXTON SEARLE, 58, St. George's Avenue, Tufnell Park, London, N.

ASSOCIATES—

Mr. JAMES HOWE, JUN., Deputy, East Cross Street, Langley Park, Durham.

Mr. THOMAS MORLAND, Back-overman, 24, Langley Street, Langley Park, Durham.

Prof. P. PHILLIPS BEDSON read the following "Results of the Analysis of Samples of New Zealand Coal and Ambrite, and of Barbados Manjak":—

RESULTS OF THE ANALYSIS OF SAMPLES OF NEW ZEALAND COAL AND AMBRITE, AND OF BARBADOS MANJAK.

By P. PHILLIPS BEDSON.

New Zealand Coal and Ambrite.

The samples were supplied by Mr. E. S. Wight, Kiripaka, New Zealand. The analyses have been made by Mr. R. Dodds, A.Sc., a student of the Durham College of Science; in the estimation of the carbon and hydrogen the method employed is that proposed by Messrs. F. Haber and S. Grinberg.*

Coal.—The proximate analysis of the coal gave :—

	Per Cent.	
Moisture	4·66	
Ash	1·10†	
Volatile hydrocarbons	47·80	
Fixed carbon	46·44	
Sulphur	0·54	
	——	100·54

The coal gives a non-coherent sandy coke.

† The ash is light in colour, and consists chiefly of alumina and silica.

The results of the estimation of the carbon and hydrogen expressed in terms of the dried and ash-free coal are :—

	Per Cent.
Carbon	74·32
Hydrogen	5·67
Oxygen and nitrogen	20·01

These numbers, and the proportion between the oxygen and hydrogen, show this coal to be most nearly related to the "dry coals burning with long flame" of Prof. Gruner's classification.

Ambrite.—The analysis of this brown transparent resin, found in association with the coal, showed it to contain 0·59 per cent. of moisture and 0·18 per cent. of ash, and the estimation of the carbon and hydrogen gave results, which, when expressed as above, are as follows :—

	Per Cent.
Carbon	80·95
Hydrogen	9·87
Oxygen	9·18

* *Trans. Inst. M.E.*, vol. xv., page 514.

This substance resembles very nearly in composition a resinous body met with in association with coal, and described by Dr. Stanek as reussinite.* In Dr. Thorpe's *Dictionary of Applied Chemistry* "ambrite" is described as:—

Brittle, semi-transparent, and of yellowish-grey colour. Its specific gravity is 1·034, and its hardness, 2. It is insoluble in most solvents, but dissolves partly in carbon bisulphide. It is said to have the composition $C_{16}H_{26}O_{7}$.†

Barbados Manjak.

The occurrence and mining of this material in Barbados has been dealt with by Mr. Walter Merivale in a paper recently read before this Institute.‡ Mr. R. L. Treble, A.Sc., a student of the Durham College of Science, has analysed the samples. His results are contained in the following tables. The proximate analysis gave:—

	Per Cent.
Ash	1·58
Fixed carbon	36·52
Volatile matter	61·90

It leaves a coke which is much larger in volume than the manjak.

Stating the results (as before) in terms of ash-free manjak, we have the following ultimate analysis, representing the proportion of carbon, hydrogen and oxygen:—

	Per Cent.
Carbon	81·18
Hydrogen	8·43
Oxygen	10·39

Prof. Dunstan, of the Imperial Institute, some time ago sent the writer a specimen of manjak, the proximate analysis of which shows it to be very similar to that described by Mr. Walter Merivale in the paper already referred to.

Manjak in appearance closely resembles albertite, analyses of two different specimens of which are given in Dr. Percy's *Metallurgy*.§ Albertite appears to contain a larger proportion of carbon and of hydrogen than manjak. Despite this close resemblance in appearance, the writer has found these materials to differ markedly in their behaviour with regard to the solvent pyridine. Pyridine is a nitrogenous base obtained from coal-tar. It is a colourless liquid, of characteristic odour, and boiling at 115° Cent. It is possessed of remarkable solvent properties, and in it manjak is completely soluble, forming a dark-brown or blackish-brown solution. Albertite, from Sutherland, is not completely dissolved by

* Dr. Muck, *Die Chemie der Steinkohle*, page 66.

† Hauer and Maly, *Jahresbericht uber die Fortschritte der Chemie und verwandter Theile anderer Wissenschaften*, 1866, page 1034.

‡ *Trans. Inst. M.E.*, vol. xiv., page 539. § 1875, vol. i., page 331.

pyridine, but only to a slight extent, and gives a yellowish solution with a slight green fluorescence. New Brunswick albertite is partially dissolved by pyridine, forming a solution like that of manjak.

In this connexion the writer may be allowed to mention some experiments on the solvent properties of pyridine. As is wellknown, many solvents, such as ether, benzene, chloroform, light petroleum-oils and phenol, dissolve some constituents out of coals. From some investigations of pyridine which were being carried out in the laboratory, the writer's attention was directed to the solvent powers of this substance, and he determined to try the action of this material on coal. Mr. F. Hooper, of the Wear Fuel-works at Sunderland, kindly placed a considerable quantity of the rectified material at his disposal, and by experiments on brown coal, a Durham coal, a specimen of anthracite and also the New Zealand coal the writer has found that pyridine dissolves out a greater proportion from some of these coals than any solvent hitherto used.

Experiments with anthracite show that neither cold nor hot pyridine dissolves any portion of the coal, while from a sample of Durham coal from 16 to 18 per cent. of the coal was dissolved by a pyridine boiling at 117 to 125° Cent., and in the case of the New Zealand coal the pyridine extracted from 10 to 13 per cent.

For some years, the investigation of the proximate constituents of coal has engaged the writer's attention, and he has sought in many ways to approach the solution of a problem as interesting as it is illusory; but he is hopeful, by the application of this solvent pyridine, that he will be able to secure some information as to the nature of some of the compounds which enter into the composition of coal.

Prof. Bedson, after reading his paper, exhibited and described the Haber-Grinberg apparatus used for the purpose of the analyses.

Mr. E. S. Wight (Kiripaka, New Zealand) said that coal-gum or ambrite occurs in all the coal-seams of the North Island of New Zealand in an elongated nodular form, the longest diameter varying from ½ inch to 9 inches. It is also found in the strata immediately over and under the seams. It is of a yellowish-brown colour, sometimes very clear, varying much in quality. It is of no commercial value, being sent away with the coal, which it helps considerably in burning, being ready to ignite; and by using a little in kindling, a fire is quickly made. It is

capable of taking a high polish, and ornaments could be made from it. It evidently originated from the vegetation which had formed the coal-seams, being similar to the gum of the kauri-tree, allowing for the pressure and other agencies which it had undergone. The coal-gum was found of the best quality, and of the greatest thickness, and as a most regular stratum in the semi-bituminous coal-seam worked at the Kiripaka mine, in the Ngunguro district of the North Island. This coal-seam varies in thickness from 3½ to 8 feet.

The CHAIRMAN (Mr. W. Cochrane) said that the illustration of the simplicity with which important chemical analyses of coal could be made would be valuable to the members, and they were indebted to Dr. Bedson for giving them an opportunity of seeing so concentrated an appliance. He asked whether ambrite was found anywhere else than in New Zealand. Was reussinite, mentioned by Prof. Bedson, found in New Zealand, and was it also found in Germany? The character of ambrite seemed to be similar, if not actually the same as that of kauri-gum found at the base of ancient forest-trees in New Zealand, and largely used for the manufacture of the finest varnishes. Did Prof. Bedson think that ambrite was of the same origin, and thus account for its being found under similar conditions?

Prof. H. LOUIS said that, as the Chairman had pointed out, ambrite had distinct analogies with kauri-gum, but the latter was practically a fossil substance. In the Malay peninsula, the natives found a resinous substance known as *dammar*, which occurred in pieces, sometimes as large as one's fist and sometimes as large as a man's head, close to the surface, in the midst of decaying vegetation, and it seemed to him that they were thus brought a step nearer to the origin of ambrite: (1) there was a fossil ambrite, lying in the midst of coal, in the roof or floor of the seams; then (2) the more recent kauri-gum, and lastly, (3) the dammar in the freshly decayed vegetation, and this seemed to complete the chain of evidence showing how these bodies had been produced. He suggested for Prof. Bedson's consideration the interest of analyses of these different substances. In the Malay peninsula, the climate closely resembled that generally supposed to have existed in Carboniferous times, and also was very similar to that of New Zealand, where ambrite and kauri-gum were found.

Mr. A. L. STEAVENSON asked whether ambrite was found in sufficient quantity to have a commercial value.

Prof. BEDSON said that reussinite was one of the resinous bodies found in the lignite near Aussig. In the earlier examinations of lignites in Devonshire, resinous bodies were found, and an analysis was given. Resinous bodies were occasionally found in the coal-seams of Northumberland, and a few years ago he had picked up pieces on the screens at one of the Cramlington collieries. He had also had a few samples of coal brought to him, from time to time, containing resinous substances. He would not venture to compare kauri-gum with ambrite, but no doubt Prof. Louis' suggestion as to its formation was a true one. The reason for which he had preferred not to speak of manjak as coal was that he called to mind a case of litigation as to whether shale was coal or not, and he did not want to commit himself to saying that manjak was coal.

Mr. GEORGE J. BINNS (Duffield) wrote that the sample of New Zealand coal appeared to be of very inferior quality, except in respect of its low percentage of ash, and resembled somewhat the analysis of a coal from Hikurangi mentioned in a paper by himself.* As regards ambrite, he might refer to the same paper,† where it was mentioned on the authority of Sir Jas. Hector as a characteristic of the "brown coal" of New Zealand, that it "contains resin in large masses," and of the "pitch coal" that it "contains resin disseminated throughout its mass." The same authority is quoted as stating that the Mataura lignite contains "abundance of ambrite (derived from a coniferous tree closely allied to the kauri of the North Island, but which has long since disappeared from the South Island)." ‡ Some details are also furnished of this fossil gum, and two analyses are given containing less carbon than that made by Mr. R. Dodds. §

Ambrite occurs not only in the North Island of New Zealand, but, as stated in his paper, very commonly in the South Island in minute specks, as well as in the masses described. He had some beautiful, though minute, stalactitic specimens from the pitch-coals of Reefton.

Prof. Louis had apparently been misinformed as to the climate of New Zealand. To quote the remarks of Sir Jas. Hector, who is in charge of the Meteorological Department :— ||

The climate resembles that of Great Britain, but is more equable. The extremes of daily temperature only varying throughout the year by an average of

* *Trans. Inst. M.E.*, vol. v., page 36. † *Ibid*, page 33.

‡ *Ibid.*, page 32. § *Ibid.*, page 77.

|| *Handbook of New Zealand*, 1886, page 60.

20°, whilst London is 7° colder than the North Island and 4° colder than the South Island of New Zealand. The mean annual temperature of the North Island is 57° and of the South Island 52°, that of London and New York being 51°.

As the Malay Peninsula lies between the isotherms of 80° and 70° in January and 80° and 90° in July, there cannot be any close similarity; in fact, a glance at the map would show an obvious discrepancy.

Ambrite undoubtedly occurs in sufficient quantities to be commercially valuable, and some years ago he communicated on the subject with the Colonial Treasurer of New Zealand, who was then in England, at the request of a large firm of varnish manufacturers, but no result was arrived at.

As the kauri-pine is named *Dammara Australis*, and as *dammar* appears to be a generic name for many kinds of fossil and sub-fossil gums, there appears to be some connection between the two words, but he was unaware of the exact relation.

The Chairman (Mr. W. Cochrane) proposed a cordial vote of thanks to Prof. Bedson for his paper and experiments. His investigations were original, and the Institute was honoured in having the record printed in its *Transactions*.

The following report of the Institute's delegate at the "Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Bristol, 1898," was taken as read:—

CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, BRISTOL, 1898.

The report of the proceedings of the Corresponding Societies Committee of the British Association for the Advancement of Science was read, and also that of Mr. T. Forster Brown, the delegate representing the Institute, as follows :—

GUILD HALL CHAMBERS, CARDIFF,
DECEMBER 13TH, 1898.

TO THE PRESIDENT AND COUNCIL OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENTLEMEN,

The British Association for the Advancement of Science meeting at Bristol extended from September 7th to September 14th, 1898.

Sir John Wolfe-Barry, in his presidential address before Section G, read an interesting paper on the Bristol and other docks, and pointed out the very large increase in the size and number of ships, due to improvements in the science of shipbuilding, necessitating larger docks, and consequently longer quays and larger warehouses. These improvements and increases, he said, have come upon us very suddenly, and were largely due to the cheapness of steam navigation and various economic causes, and within the last decade a sum of about £35,000,000 had been expended on the docks and harbours of this country. In his opinion, docks were more or less "stations" and links in the chain of transport between sea and land. He inferred that the old idea that a dock should not be held by a railway company was to some extent exploded, and pointed out the great and recent improvements at the Southampton and Hull docks which are now held by the powerful railway companies serving them, but suggested that in the amalgamation of docks and railways proper safeguards should be provided against monopoly, and protection should be given to other railways serving the docks. He also touched upon the fact that Bristol was the birthplace of the Great Western Railway, and that their famous engineer, Mr. Isambard Brunel, designed the Clifton suspension-bridge with a span of 702 feet, and it was here that the Great Western steamship of 2,300 tons was launched and ran regular voyages for 20 years across the Atlantic Ocean. Sir John also referred to Dr. Lardner's assertion at Bristol in 1836, before a meeting of the British Association, that it was impossible to construct a ship of this dimension to successfully trade between Bristol and New York, on the basis that the resistance to the progress of the ship varied according to its capacity, and that no ship, however large she might be, could carry sufficient fuel. He also referred to certain statements made by scientific men who did not base their calculations on sound principles, as, for instance, the doubt cast upon the stability of the Forth bridge on account of the wind-pressure, and on this account, and owing to the failure of the Tay bridge, the Board of Trade required provision against a wind-pressure of at least 56 pounds to the square foot, whereas the actual pressure on the Tower bridge is from 6 to 9 pounds per square foot only. This excessive precaution is directly due to the untrustworthiness of

experiments made on small surfaces. The writer, while not wishing to decry statements made by scientific men or of reviving ancient controversies, thinks that it is desirable that the true facts in relation to physical conditions should be ascertained before generalizations are made, and the importance of having a public physical laboratory was dilated upon, and he was strongly in favour of a Government institution of this kind.

An interesting paper, from an antiquarian point of view, was read on the "Newcomen Engine" at Long Ashton, by Mr. W. H. Pearson. This engine appears to have been erected so far back as 1750, and is still doing practical work. The original cost was £70. The piston is packed with rope, and has a covering of water on the top to make it steam-tight. The engine is of course worked by the vacuum formed through the injection of water into the cylinder. In the discussion which followed, Dr. Ryan calculated that it would use at least 400 pounds of steam per horsepower per hour, so that the consumption of coal for the work done must be enormous.

Mr. A. Siemens read a paper on the subject of "Electric Power in Workshops." The author stated that in 1879 Dr. Werner Siemens first introduced electric engines in Berlin. In his (the author's) opinion, electric motors will supersede horse and steam-power tramways. In electric traction 84 to 90 per cent. of useful effect was obtained, and installations were now in use employing currents of 10,000 volts, whereas a short time ago 2,000 volts was considered to be the limit. The author described the great saving in using electricity in the works of Messrs. Siemens Brothers & Company. The total cost in 1897 was 2d. per Board of Trade electrical unit and 1·71d. per brake-horsepower per hour exerted by the motors.

Mr. A. H. Gibbins read a paper on "The Application of the Electric Motor to small Industrial Purposes, and its Effects on Trade and on the Community generally," in which he pointed out the difficulty under which Great Britain especially laboured in respect to the objection to innovations which characterized the industrial world. Then there was the difficulty of first cost, which small tradesmen could not afford. The author suggested that private companies or public corporations should be instituted for the purpose of letting out small motors on hire. This system is being recognized in France, Germany, Switzerland and the United States.

A paper was read on "Electric Power and its Application on the Three-phase System to the Bristol Waggon and Carriage Works" by Mr. W. Geipel, who showed the considerable loss entailed by the use of small, scattered steam-engines. The author suggested the erection of three-phase electrical installations in preference to the direct-current system, as by the former system the motors can be left for a long time without supervision, and there is less possibility of breakdown. The discussion which followed turned chiefly on the question of continuous as against alternating currents.

Prof. Sylvanus P. Thompson read a contribution on the subject of "The Economic and Social Effects of Electric Traction," which was devoted chiefly to observations made in 1897 at Toronto, of the change made in 1893, from a very complete system of horse-tramways to a still more complete electric service. The author further stated that in Boston, U.S.A., there were 400 miles of electric tramway which would have necessitated 29,000 horses, and the gain in cleanliness was immense.

The writer (Mr. T. Forster Brown) read a paper on "The Mechanical and Economic Problems of the Coal Question." This paper had reference to the exhaustion of the more valuable and thicker seams of coal in the United Kingdom. He pointed out that at the rate of 220,000,000 tons per annum, there would in 50 years be exhausted about eleven-fifteenths of our best coal-seams. There would, however, still be thinner and inferior seams of coal left, which at an output of, say, 250,000,000 tons per annum would last about 250 years. This large residuum of thin and inferior seams would, on account of the greater depths at which they would be wrought, undoubtedly cost considerably more to work than the thick and superior seams at present in operation, notwithstanding all the skill which the mining and mechanical engineer can bring to bear upon the question. The result would be that the price of coal sold would be so increased as to raise the cost of seagoing transport, with the result that the price of our exports would naturally be higher as well as the price of the raw imports, and thereby hamper our commercial progress and prosperity, to the benefit of other nations.

The author then proceeded to show what might be saved in the cost of production by improvements in mechanical and mining appliances, etc., and to show how the higher cost above-mentioned would be to our disadvantage. With regard to Germany, although no doubt the cost of working the seams would increase in the same manner perhaps as that of our own, still this might in a certain sense be neutralized by the cheaper transit over railway and canal owing to their being in the hands of the Government. In respect to the United States, where the coal-fields are possibly twenty times the size of the British, the cost of production is now less than it is in this country. The output in that country has increased by leaps and bounds, which the following figures will show:—In 1883, it was 102,868,000 tons, in 1890 it was 140,883,000 tons, and in 1896 it was 171,416,000 tons.

In America, the railway-waggons are better adapted to coal-transport and carry less dead-weight, and consequently more profit-weight in proportion, at a cheaper rate per mile. The cost of transit on American coal is about a quarter of that charged in England. No doubt some improvement could be made in this direction by enlarging the size of the waggons.

The writer also adverted to the probable competition in the Eastern markets likely to arise through the opening-out of the vast coal-fields of China, and more especially Formosa, which is under Japanese rule, neither of which have so far been exploited to any extent.

In summarizing the several points, the writer said that no doubt the increased cost of the thinner seams might be somewhat neutralized by improvements in coal-cutting machinery, and in winding-, hauling- and pumping-engines; by checking the increase of temperature due to depth, by raising larger quantities from each shaft and by a partial readjustment of the cost of labour and royalties, the last-named even now being dealt with to a certain extent, when the conditions required it. He also reiterated his views expressed before the British Association in 1891, that the nation should acquire the railways and docks so that in case of urgency the cost of transit might be reduced to the bare working expenses. He further stated that all capital expended in drainage, water, lighting, schools, parks, etc., should be repaid within the next 60 or 65 years to admit of a permanent reduction in rates and taxes. Assuming that this country was in the same position as, say, the Continental states in regard to the railways belonging to the Government, and that the capital on the above-mentioned public works had all been repaid, then the State could reduce the cost of carrying

passengers, goods and minerals by nearly 50 per cent. In addition, the rates and taxes would be greatly reduced and the cost of living would be consequently much less. The author said that the present scheme of paying off the National Debt was no doubt a good one, but he thought that there would be ample opportunities of doing this after the above economies had been effected, which were, in his opinion, imperative.

Looking at the reverse side and assuming that the nation did nothing to guard against the contingencies he had mentioned, they would have the prospect of commercial collapse which would take place upon the exhaustion of the cheaply worked coal-seams, and they would be saddled with the burden of railways, docks, and public works, the capital of which he estimated at the sum of £1,500,000,000, with no opportunity of paying it off. The cost of manufactures would increase, with consequently a curtailment of foreign markets, resulting in a large proportion of the industrial population being thrown out of work, our income and the means of supporting our army and navy would rapidly decrease, and Great Britain would ultimately sink to the position of a secondary power.

Existing and immediately succeeding generations would therefore do well to adopt some well-matured plan for dealing with the question, and the future difficulties indicated, with the great object in view of extending the duration of the prosperity of the nation far into futurity.

Prof. O. C. Marsh, of Yale University, read a paper on "The Comparative Value of Different Kinds of Fossils in Determining Geological Age." The author said that the value of all fossils as evidence of geological age depended upon their degree of specialization. Recent forms of the same or allied genera have no distinctive characters sufficiently important to mark geological horizons, but in some cases it is totally different. From the earliest appearance of certain families the members have been constantly changing, and are thus especially fitted to assist the geologist, as each has distinctive features and an abiding-place of its own in geological time. All fossils are valuable in geology, but the comparative value of different forms needs further and fuller investigation.

The Rev. J. F. Blake read a paper on "Aggregate Deposits and their Relation to Zones." The peculiarities of certain bands he considered as evidence that the deposit was a tumultuous one, in which the material was drifted rapidly by strong currents in a horizontal direction. They were in fact the sweepings of the bottom of the sea, from the places where the fossils originally lay. For this reason the fossils belong to various dates, the actual deposit itself being necessarily at least as young as the latest fossil it contained. Such deposits may thus be distinguished as "aggregates."

Mr. R. Etheridge read a paper on "The Relation and Extension of the Franco-Belgian Coal-field to that of Kent and Somerset." The author pointed out that the coal-fields of France and Belgium occupied an extended and sinuous east-and-west line ranging through about 150 miles. In his opinion, there was little doubt that the Belgian coal-fields extended westwards to Valenciennes, Condé and Béthune, and to Calais, thence under the Straits of Dover to the recently-discovered coal-fields of South-eastern Kent. The author also referred to the present borings at Pluckley, West Brabourne, and Penshurst, the latter being 25 miles west of Dover and 1,700 feet deep. The Brabourne trial had passed through 1,875 feet of sedimentary rocks, but the bore-hole had reached a red conglomerate

of probably Old Red Sandstone age, nevertheless the boring would probably be continued. The Dover bore-hole was 2,225 feet deep, and had proved eight seams of coal, the lowest seam being 4 feet thick. This, the author pointed out, was thicker than any known seam in the Belgian coal-field.

In the course of the paper Mr. Etheridge pointed out the common characteristics of the respective coal-fields. The Bristol coal-field, he said, was 26 miles in extent from north to south, and was divided into two sections at Kingswood. The thickness of the coal-measures at Radstock was no less than 8,000 feet; the Welsh were 11,000 feet, and on the Continent they varied from 7,000 to 8,000 feet in thickness.

Mr. L. J. Spencer, in a paper on "Leadhillite, in Ancient Lead-slags from the Mendip Hills," said that lead-ores had been worked in Eastern Somerset ever since the time of the Romans, but that during the present century operations had been chiefly confined to the reworking of the old waste-heaps of slags and slimes. From these heaps upwards of 9,000 tons of lead were extracted during the 10 years ending with 1880.

Yours faithfully,

T. FORSTER BROWN.

The CHAIRMAN (Mr. W. Cochrane) proposed a vote of thanks to Mr. T. Forster Brown for his interesting report.

Mr. M. WALTON BROWN seconded the vote of thanks, which was cordially approved.

DISCUSSION OF MR. S. J. BECHER'S PAPER ON "THE NULLAGINE DISTRICT, PILBARRA GOLD-FIELD, WESTERN AUSTRALIA."*

Mr. FRANK OWEN (El Peru, Venezuela) wrote that additional interest was given to Mr. Becher's excellent paper on the Nullagine district by the fact that his official connexion with the Western Australian Department of Mines had afforded him opportunities for observation not available to many. He (Mr. Owen) had not been quite so far inland as the Nullagine district, but in 1895-96 he was in and around Marble Bar, which is some 50 or 60 miles distant, where the economic (or rather, uneconomic) conditions of mining were very similar. After the heat, what impressed him more than anything on the Pilbarra gold-field was the inefficiency of the miners available, due, no doubt, to the fact that really competent workmen could obtain much the same wages (£4 per week) on the southern gold-fields, where the climate

* *Trans. Inst. M.E.*, vol. xvi., page 44.

was not nearly so severe and food was both cheaper and better. Of course, if the developments of the mines warranted it, a railway would, to a great extent, do away with these disadvantages. When he (Mr. Owen) was in the colony, the chief obstacle to the construction of the railway was the determined opposition to the more direct route from Port Headland to Marble Bar (see map accompanying Mr. Becher's paper)* by the inhabitants of Roebourne and Cossack, who feared the diversion of trade which this would involve. From bitter personal experience, he (Mr. Owen) could fully substantiate Mr. Cadell's pointed and candid remarks on the drawbacks to successful mining in the Pilbarra district. Hitherto, with respect to the unfortunate shareholders in mining-enterprises in that district, the old saying, "Sic vos non vobis nidificatis, aves," had applied, and the local publicans and storekeepers have been the principal gainers. A genuine north-western "willy-willy," as described by Mr. Cadell, was an experience which one must go through to fully appreciate, and with large sheets of galvanized iron skimming along, end on, in all directions, no one need complain of feeling dull! He ventured to suggest that the value of Mr. Becher's paper would be enhanced by some description of the recent finds of diamonds in the Nullagine district, of which sensational accounts had been appearing in some of the mining papers.

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* Vol. xvi., Plate III., page 52.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE QUEEN'S HOTEL, LEEDS, JANUARY 28TH, 1899.

MR. W. H. CHAMBERS, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected:—

MEMBERS—

Mr. JOHN HENRY DARBYSHIRE, Assistant Manager, Ashton Green Collieries Company, St. Helens.

Mr. MAURICE GRAHAM, Civil and Mechanical Engineer, Black Bull Street, Leeds.

Mr. JOSEPH GREENSMITH, Colliery Manager, Monckton Main Colliery, Barnsley.

STUDENT—

Mr. ASHTON ASHTON SHUTTLEWORTH, Mining Student, Monckton Main Colliery, Barnsley.

The SECRETARY read the following paper on "The Rhenish-Westphalian Coal-syndicate," by Mr. George Blake Walker:—

THE RHENISH-WESTPHALIAN COAL-SYNDICATE.

BY GEORGE BLAKE WALKER.

The great and continued success of the combination of coal-owners known as the Rhenish-Westphalian Coal-syndicate has aroused much interest in this country, not unmixed with astonishment. That the coal-owners of any large district should be able to combine, to sink their individual independence, and act harmoniously with each other for the common good, borders on the incredible. Yet the Westphalian Coal-syndicate is a fact, and, as such, a brief statement of some of the leading features of its constitution, working, and results may not be unacceptable to the members.

This paper naturally makes no claim to originality. The figures are taken from the last *Year Book* (1897) *of the Mining District of Dortmund**—a work in which much interesting information as to the capital of the various mining-companies and the profits realized by them will also be found. It is wellknown that the establishment of the syndicate has been attended with the happiest results from the coal-owners' point of view; but it may be also said that it has not prejudiced the interests either of the consumer or the workman. The administration of the syndicate has been marked by strict moderation, and regard to the wider interests of the manufacturing-community of Germany. Prices fluctuate but little, and the price charged to all buyers of fuel in the same locality is the same. Thus each manufacturer knows that his competitor pays the same price for his fuel as he himself does. The coal-owner, assured of a fair profit, is encouraged to improve the conditions under which his workpeople live; and none can visit Westphalia or the Rhine Province without being struck with the prosperous appearance both of land and people. On the other hand the motto, "Union is strength," is exemplified in the treatment of wages questions; and it may be said that the coal-syndicate and the other associations of German mine-owners are the best possible guarantee against strikes.

Another result of the existence of the syndicate is evident in the magnificence of the colliery-equipment which has been developed during

* Essen: G. D. Bædeker.

the last few years. Every appliance for making the best of a coal naturally more tender than is usually the case in Great Britain, and which has to be mined under greater difficulties, owing to the flexured character of the coal-field, is brought into requisition with excellent results. One of the most striking of these is found in the high prices obtained for nuts and small coal, of which particulars are given at the end of this paper; but it may be added that these costly plants not only improve the value of the article produced, but tend materially to economize labour.

It is unnecessary to enlarge further on the advantages which the German coal-owners have derived from the establishment of the syndicate, as they are notorious.

I.—Constitution of the Syndicate.

The syndicate has its headquarters at Essen, and is established for the purchase and sale of coal, coke and briquettes. Its capital consists of 900,000 marks (£45,000) divided into 3,000 shares of 300 marks each, which can only be transferred with the consent of the syndicate.

The syndicate is conducted by:—(*a*) The management, (*b*) the board and (*c*) the shareholders in general meeting.

The management consists of a general manager and two assistant-managers appointed by the board.

The board consists of nine members, who are appointed for 4 years. Three members retire annually at the general meetings, and are eligible for re-election. Any casual vacancy is filled at the next general meeting by election. Five members of the board constitute a quorum.

The general meeting of shareholders is convened by the management, but the board also possess this power. Each share gives the holder one vote. Shareholders may attend the general meetings by duly nominated substitutes, who need not be themselves shareholders. The annual general meeting is held during the first 6 months of the financial year. Extraordinary general meetings may be convened by the board or by the managers on the requisition of shareholders representing one-twentieth of the share capital.

The business of the annual general meeting is:—(*a*) The report for the year; (*b*) the balance-sheet and remuneration of the board and managers; (*c*) the distribution of the net profit; (*d*) the election of members of the board; and (*e*) the election of auditors. At these meetings alterations of the articles of association and other like business may be transacted.

The management must present, within 3 months of the end of the financial year, a balance-sheet and profit-and-loss account, and a report on the company's operations during the past year. This balance-sheet and report must be sent to every member at least 14 days before the general meeting, together with the auditors' report.

The memorandum of association is made between the Rhenish-Westphalian Coal-syndicate and the various mines in association therewith. It sets forth that the object of the company is to obviate injurious competition on the coal-market. The various mines each severally covenant with the others, to abide by the decisions of the general meetings and of the board and the management of the company.

Meetings of mine-owners are convened as required, when every complete 10,000 tons of allotted output carries one vote. Three-fourths of the votes are required for a quorum. If this quorum be not present, the meeting must be adjourned and another summoned. At the second meeting, the decisions of the members present and voting bind the company. The chairman of the board presides. Only members or their duly authorized substitutes can attend these meetings. Third persons are not eligible. The business includes:—(1) Nomination of a council representative of the members; (2) choice of members of a commission to whom is referred the allotment of the output to be assigned to each mine; (3) decision on any recommendation of the management for a temporary restriction of output; (4) confirmation of penalties and compensation payable by or to members for excess or deficiency of output from their mines; (5) decision as to the admission of new members: and (6) confirmation of the holding of the share-capital among the associated mine-owners.

Every mine-owner, or any group of mines, is entitled to elect a member to the council for every 1,000,000 tons of annual output.

Committees may be appointed by the council to deal with particular questions.

The output-commission consists of four members, two engineers, one commercial expert, and a member of the management of the syndicate. The former are elected annually in duplicate (namely, four engineers and two commercial experts) by the mine-owners in general meeting. Should a vacancy occur during the term of office, the mine-owners appoint a substitute at the next monthly meeting. No member of the commission can adjudicate on the apportionment of output to any mine in which he is interested either as owner or employé. The commission decide by a majority of votes. In case of equality the chairman of the council acts as umpire.

II.—Pooling of Sales.

1.—Each associated colliery sells its whole production of coal, coke, and briquettes to the Rhenish-Westphalian Syndicate, which undertakes the duty of disposing of the same, in accordance with the regulations for the time being in force.

2.—Coal, etc., for the following purposes are excepted :—(*a*) Colliery-consumption and coal required for other works in connexion with the collieries, such as brick-works, etc. ; (*b*) landsale coals into carts, so long as neighbouring collieries are not prejudiced ; and (*c*) home coals for officials, workmen, etc., and free coals for charitable purposes.

3.—The disposition of the excepted coal, etc., may be controlled by the managers of the syndicate, who also settle the prices to be charged for sales by landsale, and an account of the coals disposed of under section 2 must be sent to the syndicate every month.

4.—The associated collieries pledge themselves during the continuance of the agreement to absolutely refrain from selling any coal, coke or briquettes (except as above specified) and to refer all applications and enquiries to the syndicate. Notwithstanding, every mine-owner is bound to render any assistance in his power desired by the management of the syndicate.

5.—[Contracts made prior to the formation of the syndicate in 1893 were completed under the auspices of the syndicate.]

Coke and briquettes are sold through the medium of the Westphalian Coke-syndicate and the Briquette-union, but an account of the disposal of all coal converted into coke or briquettes must be furnished to the Rhenish-Westphalian Coal-syndicate by the 5th of each month.

6.—Returns as to the quantity of coke and briquettes made must be furnished to the Rhenish-Westphalian Coal-syndicate within the same period.

7.—The Rhenish-Westphalian Coal-syndicate may in its discretion purchase coke and briquettes from non-associated collieries.

III.—Apportionment of Output.

The apportionment of output between the different collieries was originally based on the actual outputs of 1892, but these have since been modified from time, to time to meet changes in circumstances.

If a mine-owner desires his allotted output to be increased, he must give 6 months' notice to the syndicate. If the increase proposed will not necessitate a proportionate decrease in the outputs of the other associated collieries, the question is referred to and decided by the

output commission. This body considers the circumstances under which the application for an increased allotment arises, and satisfies itself that the applicant is in a position to produce the increase. Where new winnings are not in question, but the increased output is derived from mines or portions of mines in which operations have been suspended, the commission must (with due regard to the demand on the market for the particular class of coal in question) give the preference to mines which have been closed for a longer as against such as have been suspended for a shorter period. If either the mine-owner or the managers of the syndicate are dissatisfied with the decision of the output commission they may appeal against such decision to the council within 14 days of the notification of the decision of the commission. When an increase in output has been granted to any colliery it takes effect from April 1st or October 1st next following, and at no other time.

Every colliery is bound to deliver its allotted output, unless 4 weeks' notice has been given to the syndicate of a reduced delivery. The various collieries owned by one company are dealt with as a whole. Collieries may also, if they wish, group themselves by giving notice at the commencement of any financial year, and such groups are in like manner dealt with conjointly.

Should the state of the market necessitate a reduction of the output, a percentage reduction of the allotted output of each mine is notified, and such reduced output is the maximum permitted for the time being.* If it should be necessary to reduce the production of particular classes of coal in a greater degree than others, the mines having the larger apportionment must contribute *pro rata* to those whose apportionment is smaller. In such cases the syndicate furnishes a statement every month of the mines which have exceeded or have not worked up to their quantity, but no payments are made in connexion with these adjustments until the end of the year.

IV.—Regulation of Prices, etc.

The Rhenish-Westphalian Coal-syndicate acts as sales-agency for the associated collieries, and pays over to them the moneys received, subject to an allowance for expenses. The syndicate has to bear any bad debts that it may make. The management of the syndicate fix the sale-prices and the conditions of delivery, and these are based on a general average for coals of like quality and size. Modifications to equalize the actual

* In the autumn of 1898, the output of the associated collieries was temporarily reduced by 7 per cent., owing to scarcity of railway-trucks, which were at that time required for grain and harvest traffic.

market-value of the produce of each particular mine are made by the managers, and it thus results that though competition in selling is obviated a mine may improve its selling-price by improving the quality of its product (as by washing, sizing, etc.). If any colliery considers its prices unfair as compared with others, it may make an appeal to the council, by whom the complaint will be considered and dealt with.

Each colliery is responsible for the proper execution of orders received from the syndicate, and any deductions made for inferior quality or other reason must be borne by the colliery.

V.—Expenses.

To cover the expenses of administration of the syndicate and its business operations, a proportional deduction is made from the amounts payable monthly to the associated collieries. The amount of such deductions is determined by the council.

VI.—Penalties.

Any associated colliery selling coal, coke or briquettes contrary to this agreement is subject to a penalty of 50 marks (£2) per ton.

Any failure to deliver the apportioned output involves a penalty to be fixed by the council at the end of the financial year.

For any other breach of the provisions of the agreement a fine of 1,000 marks (£50) may be imposed.

An appeal against a penalty may be made by a member to the general meeting of mine-owners.

The penalties are deducted from the amounts due to the offending colliery in the hands of the syndicate.

In addition to any penalty, a member who has broken the rules of the association is liable for any actual damages which the syndicate may have sustained through his action.

The present agreement will terminate on December 31st, 1905.

VII.—Operations of the Coal-Syndicate in the Years 1895 and 1896.

On March 1st, 1893, at the inauguration of the syndicate, the total output apportioned among the associated collieries was 33,575,976 tons, rising at the end of 1893 to 35,531,116 tons, in 1894 to 37,988,233 tons, in 1895 to 40,722,804 tons, and ultimately in 1896 to 42,626,516 tons.

The increase in the gross allotted output at the end of 1895 as compared with March 1st, 1893, was therefore 7,146,028 tons, equal to 21·28 per cent. Evidently it was not possible for the vend to increase to the same extent in so short a time. The inevitable consequence of

this was a *pro rata* reduction in each of the following years, as shown in the last column of the following table :—

Year.	Total Apportioned Output.			Vend.			Actual Diminution.	
	Tons.	Increase compared with previous Year.		Tons.	Increase compared with previous Year.		Tons.	Per Cent.
		Tons.	Per Cent.		Tons.	Per Cent.		
1893	35,371,917	—	—	33,550,436	—	—	1,821,481	5·15
1894	36,978,603	1,606,686	4·54	34,993,116	1,442,680	4·30	1,985,487	5·03
1895	39,481,398	2,502,795	6·77	35,354,842	361,726	1·03	4,126,556	10·45
1896	42,626,516	3,145,118	7·96	38,916,112	3,561,270	10·07	3,710,404	8·71

The following table shows the relations of the gross allotted output, the actual output, colliery-consumption and sales for each month of the year 1896 :—

Month.	Gross Allotted Output.	Actual Output.		Colliery Consumption, etc.	Sales.		
		Tons.	Percentage of Allotted Output.		Total.	Dealt with by Syndicate.	
						Tons.	Per Cent.
	Tons.			Tons.	Tons.		
January ...	3,461,985	3,340,930	96·50	800,650	2.514,026	2,305,696	91·71
February ...	3,452,285	3,094,014	89·62	741,545	2,329,702	2,128,534	91·37
March ..	3,501,148	3,091,416	88·30	770,282	2,334.332	2,154,538	92·30
April ..	3,348.690	2,952,011	88·15	748,382	2.207,047	2,037,486	92·32
May ...	3,558,619	2,974,512	88·56	766,028	2.228,173	2,069,491	92·88
June ...	3,481,407	3,080,661	88·49	772.733	2,315,003	2,163,798	93·47
July ..	3,810,876	3,394,974	89·09	807,381	2,574.396	2,406,850	93·49
August ...	3,686,104	3,300,268	89·53	777.196	2,532,955	2,356,634	93·04
September	3,688,638	3,386,069	91·80	779,064	2.606.658	2,423,764	92·98
October ...	3,887,655	3,584,622	92·21	839,024	2,724 651	2,527,645	92·77
November...	3,453.415	3,338,203	96·67	803,335	2.548,598	2,348,096	92·13
December ...	3,495,693	3,378,431	96·65	827,119	2.562,329	2,367,527	92·40
Totals ...	42,826 515	38,916,111	91·29	9,432,739	29,477,870	27,290,059	92·56

It will be observed that in 1896 most favourable results were obtained in the months of January, September, October, November and December, the diminution amounting only to 3·33 per cent. in November (minimum) to 8·20 per cent. in September (maximum). For the other months there was but little fluctuation between a minimum of 10·38 per cent. in February to a maximum of 11·85 in April. In the previous year fluctuations were more marked. The explanation of the remarkable steadiness of the output in 1896 is that it was due to the favourable combination of great activity in all branches of industry, with a sufficiency of water in the Rhine, the traffic on which is sometimes much restricted in summer owing to the shallowness of the river.

Colliery-consumption amounts to the large figure of 9,432,739 tons, or 24·24 per cent.; but this includes the coal used for coking and briquette-manufacture, as well as the coal consumed at the collieries.

The competition of Great Britain was keenly felt in Hamburg and Holland, whereas an increased quantity of coal of 150,000 tons was sent into Belgium. The actual output in 1895 was 10·45 per cent. under the total apportioned output, and in 1896 it was 8·71 per cent.

VIII.—Standard and Actual Prices of the Rhenish-Westphalian Coal-syndicate for 1897-98.

The council of the Rhenish-Westphalian Coal-syndicate, at its meeting at Essen on January 26th, 1897, fixed the standard prices for 1897-98. The standard prices are, as their name implies, the basis for the sales of the syndicate. These sales were based on the existing rates at that time, but considerably better prices were subsequently obtained. In future, it is proposed to fix the prices on April 1st instead of January 1st, as this appears to be a more convenient time of the year and allows time for the delivery of uncompleted balances of contracts. The following tables, divided into the classes:—Fat coals, gas coals, and steam and dry coals, may be roughly considered to correspond to the English classification of house coal, gas coal, and steam and manufacturing coals:—

I. -Fat Coals.

Description of Coals.	Old Standard Prices.	Actual Selling Prices for 1897-98.	New Standard Prices.
	M.	M.	M
Through and through	6·50	6·50—7·00	7·00
Coal containing about 25 per cent. of lumps	8·00	8·30—8·60	8·50
,, ,, 40 ,, ,,	8·50	8·75—9·10	9·00
,, ,, 50 ,, ,,	9·00	9·30—9·60	9·50
Smithy coal	8·50	8·50 -9·10	9·00
Screened smithy coal	9·00	9·00—9 60	9·50
,, ,,	9·50	10·00	10·50
,, ,,	10·00	10 50	10·00
Double screened	10·50	11·50	11·00
Washed coal (mixed)	9·50	10·00—10·30	10·00
Washed nuts I.	10·00	11·00—11·30	10·50
,, ,, II.	10·00	11·00—11·30	10·50
,, ,, III.	9·00	9·50— 9·80	9·50
,, ,, IV.	8·00	8·50— 8·80	8·50
Unwashed nuts above 30 millimetres	7·50	—	—
,, ,, up to ,,	6·00	—	—
Coking coal	6·50	7·00— 9·00	7·00
Washed smudge	5·00	—	6·00
Unwashed ,,	4·00	—	5·00
Washed peas	7·00	7·50	7·50
,, 50 millimetres	6·00	7·00	6·50
Slurry or fine duff	4·00	5·00	4·00

II.—Gas Coals.

Description of Coals.	Old Standard Prices.	Actual Selling Prices for 1897-98.	New Standard Prices.
	M.	M.	M.
Gas coal (unscreened)	10·00	10·00 10·50	10·00
Generator coal	9·50	9·75 –10·25	9·75
Fire coal	8·75	9·25— 9·50	9·25
,, ...	7·75	8·75	8·25
Engine coal	8·25	8·75 – 9·25	8·75
Partially screened gas coal	10·00	10·00–10·50	10·50
,, ,, ,, ...	10·50	11·00–11·50	11·00
Double screened ,, ...	11·00	11·50–12·50	11·50
Washed gas nuts I.	10·50	10·75–11·00	11·00
,, ,, II.	10·50	10·75– 11·00	11·00
,, ,, III.	9·50	9·75–10·25	10·00
,, ,, IV.	8·50	8·75 – 9·00	9·00
,, ,, V.	7·00	7·25– 7·50	7·50
Unwashed gas nuts I.	10·00	11·00– 12·00	10·50
,, ,, II.	10·00	11·00- 11·50	10·50
,, ,, III.	9·00	9·00	9·00
,, ,, IV.	7·00	7·75	7·50
Gas pea coal 0·60 millimetres I.	7·00	7·00 – 7·50	7·50
,, 0·30 ,, II.	6·50	6·50 – 7·00	7·00
,, 0·15 ,, III.	5·50	6·00 – 6·50	6·00
Screened small coal	4·50	5·00–5·25	5·00
Washed small coal	5·00	5·50–6·00	5·50
Smudge	7·00	7·50	7·50
Slurry or fine duff	4·00	4·50–5·00	4·00

III.—Forge, Steam and Dry Coals.

Description of Coals.	Steam Coals.			Dry Coals.		
	Old Standard Prices.	Actual Selling Prices for 1897-98.	New Standard Prices.	Old Standard Prices.	Actual Selling Prices.	New Standard Prices.
	M.	M.	M.	M.	M.	M.
Screenings	4·50	5·50	5·00	3·50	4·50	4·00
Through and through	6·50	6·50—7·00	7·00	6·50	6·75	6·75
Coal with 20 per cent. of lumps	7·00	7·50–8·00	7·50	7·00	7·50	7·50
Coal with 30 per cent. of lumps	8·00	8·00–8·50	8·00	7·50	8·00	8·00
Coal with 50 per cent. of lumps	9·00	9·50	9·50	8·50	9·00	9·00
Round coal	11·00	11·00–11·50	11·00	10·50	11·00 -13·00*	11·00
Cobbles	—	—	-	11·00	11·50 – 13·50*	11·50
Washed cobbles ...	—	—	—	12·50	12·50—14·50*	13·00
Washed nuts I. ..	12·00	12·00 – 13·00	12·00	13·00	13·00 – 15·00*	13·50
,, ,, II. ..	11·50	12·00 - 13·00	12·00	13·00	13·00 15·00*	13·50
,, ,, III. ..	9·00	10·00	9·50	9·50	10·50 – 12·00*	10·00
,, ,, IV. ...	7·50	8·50—9·00	7·50	7·50	8·00 - 8·25	8·00

IV.—Steam Coals.

Description of Coals.	Old Standard Prices.	Actual Selling Prices.	New Standard Prices.
	M.	M.	M.
Screenings	4·50	5·50	5·00
Through and through	6·50	6·50— 7·00	7·00
Coal with 20 per cent. of lumps	7·00	7·50— 8·00	7·50
,, 30 ,, ,, ...	8·00	8·00— 8·50	8·50
,, 50 ,, ,, ...	9·00	9·50	9·50
,, 60 to 70 ,, ,, ...	9·50	—	10·00
Round coal I.	10·50	11·50	11·00
,, II.	10·00	11·00	10·50
Washed nuts I.	11·50	12·00 13·00	12·00
,, II.	11·00	12·00—13·00	12·00
,, III.	9·00	10·00	9·50
,, IV.	8·00	8·50— 9·00	8·50

V.—Semi-dry Coals.

Description of Coals.	Old Standard Prices.	Actual Selling Prices.	New Standard Prices.
Screenings	6·50	6·75	6·75
Coal with 20 per cent. of lumps	7·00	7·25	7·25
,, 25 ,, ,, ...	7·50	7·50— 7·75	7·75
,, 35 ,, ,, ...	8·00	8·00— 8·25	8·25
,, 45 ,, ,, ...	8·50	8·75— 9·00	9·00
Best mixed coal with 60 per cent. of lumps ..	9·50	9·75—10·00	10·00
,, ,, 75 ,, ,, ...	10·00	10·75	10·50
Cobbles	12·00	12·50	12·00
Washed nuts I.	11·00	12·00	12·00
,, ,, II.	10·50	12·50	12·00
,, ,, II*b*.	9·00	10·00—11·00	10·00
Unwashed nuts III., 10 to 20 millimetres ...	6·50	7·00	7·00
Washed nuts IV., 5 to 15 millimetres... ...	7·00	7·00	7·50
Nut slack	5·00	5·50	5·00
Smudge	4·00	4·50	4·50
Slurry or fine duff...	2·00	3·00	2·00

VI.—Dry Coals.

Description of Coals.	Old Standard Prices.	Actual Selling Prices.	New Standard Prices.
Through and through	6·50	6·75	6·75
Coal with 20 per cent. of lumps	7·00	7·25	7·25
,, 25 ,, ,, ...	7·50	7·50— 7·75	7·75
,, 35 ,, ,, ...	8·00	8·00— 8·25	8·25
,, 45 ,, ,, ...	8·50	8·75— 9·00	9·00
Best coal with 60 per cent. of lumps	9·50	9·75—10·00	10·00
,, 75 ,, ,, ...	10·00	10·75	10 50
Cobbles	12·00	12·50	12·00
Unwashed nuts III.	6·00	—	—
,, ,, IV.	6·00	—	—
Washed nuts III., 4 to 20 millimetres... ...	6·50	7·00	7·00
,, IV., 5 to 15 ,, ...	6·50	6·00— 7·00	6·50
Nut slack	5·00	5·50	5·00
Smudge	3·50	4·50	4·00
Washed smudge	4·00	—	—
Slurry or fine duff...	2·00	3·00	2·00
Washed anthracite nuts I.	15·00	17·00	16·00
,, ,, II.	18·00	19·50	19·00
,, ,, III.	9·00	10·00—11·00	10·00

The PRESIDENT (Mr. W. H. Chambers), in moving a vote of thanks to Mr. Walker for his paper, remarked that the circumstances in which the syndicate could work in the Westphalian coal-field were by no means parallel with those with which they had to deal in Yorkshire. He thought that the attitude of the public would be different; they would be opposed to any similar association being instituted in this country, and Parliament might be inclined to interfere with it as tending to the restriction of trade. Capital in foreign countries was much freer in this respect than in our own country, largely owing to the greater difficulty in obtaining it for such purposes. Competition in Westphalia was limited to a greater extent than elsewhere, as the coal-fields of Saarbrücken, Upper Silesia and Lower Silesia were the only competitors. The subject most interesting to the members was the improvement which the owners of Westphalian collieries had been able to make in the selling price of coal, owing to the washing and sizing of the coal. Although the coal was inferior, the owners had been able in many districts to substitute their washed coal for coal from this country.

Mr. HAROLD BONSER (Leeds) remarked that the underground workings of Westphalian collieries did not compare favourably with British collieries. The tender nature of the Westphalian coal necessitated special treatment, and, at the collieries in the neighbourhood of Essen, the arrangements of the surface-plant were admirable. The Germans were quick to perceive the necessity of utilizing their resources by making the coal into coke, and utilizing the tar and other constituents, including potassium cyanide, which was worth 9d. per ton of coal calcined. They almost monopolized the trade in that chemical, which had superseded mercury in gold-recovery processes. A waste occurred at present, from throwing coal-slack into the gob; and that coal-slack was better than the best Westphalian coal.

Mr. C. C. ELLISON (Monckton Main colliery) said that the owners of new collieries which had been sunk in this country, and which were cheaply worked, might be adverse to joining a syndicate owing to the restriction it might impose to the expansion of their output. He, however, thought that the enhanced value of the produce would make up for this loss. He believed that the influence of such syndicates on trade would prevent the selling price from being subject to fluctuations; thus every manufacturer in Westphalia knew what he was going to pay for his coal for at least 12 months, and those competing in foreign markets

were certain of being able to carry out their contracts without loss. The various savings resulting from the working of a syndicate would enable prices to be so regulated that, while giving a proper return on capital, collieries would be able to sell in foreign markets with such a margin as would enable them to meet all competitors without unduly reducing prices. Further, a syndicate would enable a more regular rate of wages to be paid, owing to a remunerative selling-price being maintained.

Mr. J. Nevin (Mirfield), referring to the tables, remarked that the syndicate seemed to have apportioned a larger output than they could find a market for.

Mr. T. W. H. Mitchell (Barnsley) thought that a most important lesson was to be learnt from the tables, showing the number of varieties and sizes of coal, and the various prices obtained. The members would notice, in nearly every instance, that where round coal reached, say, 10·50 to 11 marks, washed nuts became more valuable than round coal. The paper showed that mining-engineers should devote more attention to the screening and cleaning of coal. and thus the only coal sold below the actual cost of working would be the very small dust. A paper upon the screening and cleaning of coal, showing what prices could be obtained for the various sizes of coal, would be of great benefit and interest to the members. In Yorkshire, they were satisfied with 60 to 75 per cent. of round coal, and the nuts and slack were sold below their actual value, because these had not been treated as they should be to constitute a better quality of coal, and the consumer did not know the value of smaller sized coals.

Mr. H. B. Nash (Barnsley) said that Mr. Walker's paper showed that the difference in selling-price between washed and unwashed coal was 6d. per ton, and the members should consider whether they could erect a washing-apparatus, wash the coal, redeem their capital, sell the cleaned material in Great Britain, and make a profit out of the enhanced price of 6d. per ton. He thought that there were so many coal-producing centres competing with one another, and able to produce 10 to 15 per cent. more coal than consumption required, that a syndicate would not be beneficial, as in times of bad trade the cost of production (owing to reduced outputs) would exceed any benefit obtained from the increased selling-price of the reduced output.

Mr. E. W. Thirkell (Oaks collieries) remarked that Mr. Walker's paper was a commercial rather than a practical treatise, but certain con-

siderations arose out of it which had a practical bearing. One was the enhanced value of the coal produced by better treatment, and the other arose from the syndicate having the sales in their own hands for a certain period, whereby the owners were safe from any stoppage of the collieries through any action of the men in view of an advance of wages. He had pleasure in seconding the motion that the thanks of the members be given to Mr. Walker for his paper.

Mr. H. St. John Durnford (Ackton Hall colliery) wrote that a federation regulating the sale of coal in Great Britain would be desirable, but he feared, as British markets for coal were so widely spread and shipping ports so numerous, that a workable scheme would be an impossibility. He understood that the chief manufacturing-districts of Germany could be economically supplied from the Westphalian coal-field alone, and the tonnage sent outside of the district is not large.

The President thought that the special usefulness of the paper to the members was to draw their attention particularly to the treatment of coal. Mr. Walker's paper illustrated very forcibly how the prices and the suitability of the fuel for the purpose for which it was required were attained by proper sizing, cleaning and treatment of the coal after it was wrought.

The motion was carried.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
JANUARY 9TH, 1899.

MR. J. C. CADMAN, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were confirmed.

The following members, having been previously nominated, were elected :—

MEMBER—

Mr. SAMUEL ATHERTON, Coalowner, Hanwood and Shorthill Collieries, near Shrewsbury.

STUDENTS—

Mr. JOHN ARTHUR COLE, Biddulph Valley Iron-works, Stoke-upon-Trent.

Mr. ARTHUR BERNARD HEWITT, Whitfield Collieries, Norton-in-the-Moors, Stoke-upon-Trent.

Mr. C. E. de Rance's paper on "Horizontal Thrusting in Joints," etc., was read as follows :—

HORIZONTAL THRUSTING IN JOINTS, MINERAL VEINS AND FAULTS IN THE NORTH-WEST OF ENGLAND, ETC.

By C. E. de RANCE.

1. *Joints.*—The attention of the author was first drawn to the evidence of horizontal thrusting when examining the faces of the joint-planes traversing the Inferior Oolite of Dorset, in the neighbourhood of Bedminster, and those traversing the Grey Chalk and Lower Chalk of Eastweir Bay and Abbot's Cliff between Folkestone and Dover so far back as 1865, in which year he published a communication as to Kentish Geology.* In both cases the joints ran parallel to a neighbouring fault, the slickensides on the fault-planes were inclined, pointing to vertical and horizontal displacement, while the slickenside markings on the joints were normally horizontal, or but very slightly inclined. The adjacent or "country rock" was often as much indurated and altered in the case of the joints, as in the case of a fault, and in both cases, is most marked on the upcast, or stable portion (as might be expected), the movement, whether vertical or horizontal, being distributed over a considerable area, caused the amount of friction to be increased by the grinding weight of the moving mass above.

In the chalk-pits near Hertford, Lewes, and in South Hants, examples may be seen of joints altering their hade, in accordance with the comparative hardness of the chalk-bands traversed by the divisional plane, which are constantly found to be hardened and smoothed to an almost marble-like surface, which does not chalk-mark the fingers, and are occasionally beautifully striated with fine markings, as if they were produced with a needle-point.

The conclusion formed by the author in 1865, was that joints may be regarded as planes of horizontal motion, but that where the slickensides are inclined at an angle a certain amount of vertical throw must have taken place, but this does not of necessity prove that the divisional plane is really a fault and not a joint. Exposures of deep vertical faces of faults and joints are rare, the latter especially so, but it would appear that in their case the slickenside striæ are restricted and local,

* *Geological Magazine*, 1865, vol. ii., first decade, page 527.

and cannot be followed in depth. Further, both in the Devonian Limestones near Plymouth, and in the Fourth Millstone Grit near Anglezark Moor, Chorley, Lancashire, the slickensides are not unfrequently in two sets, at a somewhat different angle, giving the idea of a double push, partly forward, partly downward, and a recoil from both, in other words, a see-saw motion.

A joint was recently observed by the writer in a slate-quarry, near Carmarthen, in the Llandeilo Beds, a fault traversed and cut across both bedding- and cleavage-planes, which latter were at right angles to one another. Parallel with this fault was a joint-plane striking east-north-east, with a hade of 70 degrees to the south, the face being slickensided at an angle of 45 degrees from the east-south-east, pointing to a horizontal and vertical movement towards the west-north-west. If sporadic and local, this movement does not necessarily imply that the divisional plane was a fault and not a joint. On the other hand, Prof. James D. Dana, in his *Manual of Geology* (New York, 1880). states "joints in rocks are planes of fracture or division, cutting directly across the stratification and extending through great depths. The planes of division are often as even, as if a thin blade had been drawn through with a clean long stroke. These joints may be in one, two, or more directions in the same rock, and they often extend with nearly uniform courses through regions that are hundreds of miles in length or breadth."* He adds, "the main system of joints is usually parallel to the strike of the uplifts, or else to the range of elevations or mountains in the vicinity, or to some general mountain-range of the continent; and the directions are studied with much interest, because of their bearing upon the geological history of the country."

This testimony is of importance, for if the views advanced be correct, it tends to show that shifting has taken place horizontally over hundreds of miles in the United States of America without vertical displacement. The writer is doubtful as to whether it necessarily follows that the joints continue down to a vast depth, a continuance which, if the view advanced be correct, would entail horizontal movements of enormous vertical masses. His own experience in the British Isles is that joints have a tendency to die out in depth, and originate from surface-thrust.

The late Prof. Beete Jukes pointed out that, without natural joints, the quarrying of stratified rocks would be very difficult, and of unstratified rocks almost impossible. For the production of quarry-

* *Loc. cit.*, page 99.

blocks of stone "there must clearly be at least two sets of joints in stratified, and three sets in unstratified rocks, each set more or less nearly at right angles to each other."* To master joints traversing granitic rocks, at considerable widths, without the occurrence of cross-joints, the possibility of obtaining monoliths of granite from Egypt in the past, and from Newfoundland and the Island of Mull in the present is due. Prof. Jukes points out that master joints in a limestone-quarry near Foynes were "as much curved as the side of a ship, only waving backward and forwards in length so as to curve now on the one side and now on the other of the perpendicular,"†

Prof. Jukes evidently gave great attention to joints, and it is therefore important to follow him in his deductions. He points out that joints vary from the close, regular and symmetrical to the irregular and uneven, in proportion to the fineness of the grain of the rock or its coarseness, and he lays stress on the fact that the force that produced the joint, has often made a clean cut through pure white quartz-pebbles, but he does not state whether both halves of the pebble remain on either side of the divisional plane. It is obvious that if the pebble is simply cut in two, no movement in any direction has taken place. Prof. Jukes points out that joints in shales are always close, a statement which the writer endorses, and has noted the same in clays of Secondary, Tertiary and Post-Tertiary age, and in all he has noticed more or less horizontal striation in the slickensides. Both in the Chalk of the South-east of England, in the Carboniferous Limestone of Grange, North Lancashire, and in the mass of limestone south of Cross Bank, by the high road from Sedbergh to Kirkby Stephen, open and close joints occur, and the former in both formations form fissures, through which water flows in what may be considered "a defined channel." The joints that are closed invariably traverse chalk, or limestone of the same hardness and general consistence; those in which fissures have been left consist of alternation of bands of somewhat different hardness, the vertical length of the fissure corresponding to the thickness of the softer bed.

In Swaledale, in Yorkshire, there are many examples of horizontal joints in the Yoredale limestone: these invariably following the planes of bedding, which have a gentle easterly dip, at an angle somewhat greater both in the valley of the Swale and that of the Ure (or Yore) than that of the stream-bottom. Consequently in descending these

* *The Student's Manual of Geology*, Edinburgh, third edition, 1872, page 175.

† *Ibid.*, page 177.

rivers, higher and higher beds are reached, and in their entirety they exhibit a sequence of the whole of the Yoredale series of Prof. Phillips. From many of these horizontal joints, what may be called ready-made streams issue, and falling over the underlying shale, make picturesque water-falls on the sides of the escarpment: a good example may be mentioned, on the north side of the road between Askrigg and Muker, on the Swaledale side of the pass, above Mr. Bainbridge's house. The wellknown Carshalton springs, forming the chief source of the Wandle, which has been declared by a Parliamentary Committee, though underground water, "to flow in a defined channel," are probably an example of the same phenomenon occurring in the Chalk formation.

In horizontal, or rather dip-plane joints, the writer has so far found no trace of another set cutting across them, like those, which by intersection of two systems more or less at right angles to each other, render it possible to obtain cuboidal or quadrangular blocks in quarries, and when the planes are at an angle to each other, of a more or less prismatic shape, except in the case of granite, and the coarser andesitic rocks where horizontal joints produce the semblance of bedding and are cut off by the "master joints" of the quarrymen, these joints being obviously of later origin than the pseudo-bedding-planes referred to. Good examples of this occur in the granites and andesites of the Lake District, and it is, perhaps, needless to point out that the trap-rocks obtained their name from this pseudo-bedding, caused by horizontal jointing, from the Swedish word *trappa*, "a stair." If the view taken be correct, each step of the Swedish trappean hills may be regarded as a distinct thrust-plane following each other in succession in time. In the correct appreciation of the natural advantages permitted by the system of joints lies the whole art of quarrying.

The prismatic jointing known as columnar structure, noticeable in basalts and in many dykes is invariably at right angles to the planes of consolidation, each layer marking successive planes of cooling, and has nothing in common with the jointing described. Mr. Gregory Watts' experiments prove that the columnar structure of basalts can be reproduced artificially.

2. *Mineral Veins.*—The researches of the writer have been restricted to the Carboniferous Limestone of the Mendip Hills, South Wales, North Wales, North-west Yorkshire, North Lancashire, Cumberland and Westmoreland, and more especially the Whitewell district near Clitheroe, and Alston Moor, in which areas he has examined the majority of the mines

in great detail. The phenomena observable appear to point to similar conditions of more or less horizontal movements noticed in the divisional planes known as "joints," and the more a mineral vein conforms to a joint rather than to a fault, the more prolific it is found. In Alston Moor, it may be stated that the ore-yield of a vein is in an inverse proportion to the amount of throw, the smaller the vertical displacement the greater being the yield. The Mountain Limestone in the Cross Fell and Alston Moor districts is split into alternations of various beds, the limestones of which are wellknown to the local miners, and the distinctive character and names of which have long since been recorded by Messrs. Westgarth Foster, Sopwith, Wallace and others. The chief limestones down to the intrusive Whin Sill, are the Little Limestone, the Tumblers or Great Limestone, 70 feet thick, the Scar 180 feet, the Cockle Shell 18 inches thick, full of *Productus*, the Tyne Bottom Limestone about 24 feet thick, resting on a thin coal-seam (which the writer found in 1873 turned into impure graphite at Smith's Gill near Garrigill), over the surface of the Great Whin Sill which is there 110 feet thick. Below it are 900 feet of measures with several limestones, the chief being the Melmerby Scar, 124 feet thick, this has not been reached in any of the Alston Moor mines, nor have any of those lying above the Whin Sill and much below the saturation-plane of the underground water in the South Tyne valley below Cross Fell. The strata lying above contain 200 feet of limestones, 350 feet of sandstones, and 520 feet of shales, some of the latter, like the Tyne Bottom Plate, 50 feet in thickness, overlying the Tyne Bottom Limestone, extending over wide areas. The word "plate" is used locally for shales, and "hazle" for sandstones, certain beds of the latter being known as the Copper Hazles, from that mineral being disseminated through their mass, in small crystals of sulphide of copper, just as galena-crystals are distributed in the country-rock of the Sykes veins in the Trough of Bolland, between Lancaster and Clitheroe.

Mr. W. Wallace, in his remarkable work, *The Laws which Regulate the Deposition of Lead-ore in Veins* (London, 1861), has clearly shown and supported by examples four general laws governing the distribution of lead in his own area (Alston Moor), and stated in abstract, they are:—

(*a*) That the quantity of water in circulation below the summit of a hill is in inverse proportion to the depth from the surface, and in direct proportion to the distance from the watershed. Therefore, the farther from the watershed or the dip of the measures, the greater the quantity of water.

(*b*) The steeper the hill-slope, the less water under it; the smaller the inclination, the more the water.

(*c*) The freeness of the circulation of water near the surface is directly proportional to the amount of inclination of the beds, faults, joints, or veins towards the side of a hill, or *vice versa*.

(*d*) The greater number of veins, faults, intersecting large lodes, etc., the greater the circulation, especially when corresponding to the dip of the strata, and therefore the greater is the chance of the lode to which they run being ore-bearing.

These considerations assume that the veins are filled from above with minerals in chemical solution in water, deposited in fissures previously existing.

Thrust-planes are in evidence in a bye-wash of one of the reservoirs on the Roddlesworth, near Lower Whitbank Tockholes, in a vein of sulphide of lead ranging west 25 degrees north; the back of the lode is quartz, which is distinctly striated at an angle of about 15 degrees from the horizontal. The hill-side and beds (base of Third Millstone Grit) dip towards the lode, which is a small strike-fault running parallel to the stream, which, if consisting of an open fissure, would tend to be filled with any substance that the water could mechanically remove, or chemically unite with, from the grit and sandstone above.

On the south-western side of the same tract, east of Chorley, west-south-west lead-lodes occur between White and Black Coppice Anglezark Moor. The quartz backing of the vein is here also obliquely striated, the formation being the Kinderscout Grit. Further south, at Stronstrey Bank, occur several shafts which indicate blende, sulphide of lead and copper pyrites, in which Witherite was first discovered by Dr. Withering after whom it was named.[*] The writer was not able to examine the shafts. Twelve miles north-east of these sections and 4 miles south-east of Burnley, the Thievley fault ranges east-and-west, and throws down to the north 1,020 feet, on the breast of a hill, nearly 1,500 feet in height; the Arley Mine coal-seam on the downcast side being thrown against the Rough Rock of the Millstone Grit. Here the fault is a true fissure-vein containing galena, and the foot-wall of the fault-lode is diagonally striated. So also is the lead-mine fault at Hambledon Hill, 1,380 feet above the sea, 2 miles east of Accrington; here the Arley Mine coal-seam, on the downcast side of the fault, contains strings of galena passing away from the fault. The writer noticed cubes of galena in the Kilkenny Four-feet coal-seam near Clonbrock, in Queen's County, Ireland: it was worthy of note that Dr. Hull considered this coal to be the equivalent of the Lancashire Arley Mine.

[*] Prof. Phillips' *Introduction to Mineralogy*, London, 1837.

In the West Riding of Yorkshire, is an anticlinal axis described as the Sykes axis, by Mr. Tiddeman of the Geological Survey, who mapped the area, which brings to the surface, in the Sykes, Brennand and Whitendale valleys below certain grits and shales, a crystalline dark warm-grey limestone, weathering red, locally known as the Red Bed Limestone 80 feet thick, shales, Lower Post Limestone 78 feet, shales and cherts, then the Six Fathoms Limestone pale grey and compact 38 feet, shale, and then the Twelve Fathoms Limestones, containing grains and crystals of galena. The lodes in it are invariably obliquely striated, the sides often consisting of magnificent crystals of barium sulphate, often studded with fluorspar crystals, some of them colourless and sprinkled over with lead sulphide and copper pyrites. In the Brennand mine, the hade of the lode is 55 degrees from the horizontal on an average up to 84 degrees in the harder limestones, and down to 38 degrees in the soft shales. With limestone to limestone, the lode is well defined, filled with lead and other minerals, occasionally with spaces or loughs intervening, the sides of which were covered in No. 5 South Level Brennand mine, with brilliant crystals of carbonate of lime, inclining towards the hollow, resting on a foot-wall of iron pyrites, beautifully indented with slickensides, ridge and furrow being as large as one's finger, sloping at an angle of 12 to 15 degrees, pointing to an overthrust that had removed the original contents of the lode and left it unproductive.

3. *Faults.*—A great deal has been written, as regards trough-faults, by Mr. Hopkins,* Prof. Phillips † (Malvern Hills), and Prof. Beete Jukes.‡ Their explanation was that trough-faults originated during upheaval, when the area containing such faults became for a time an anticlinal with fractures, and that down these fractures the trough-shaped masses slipped ; when the area settled down again into an approximately horizontal position the gaps closed up with great lateral pressure. Prof. Jukes pointed out that the coal in South Staffordshire on each side of a trough-fault was reduced to powder by the pressure. The writer's late colleague, Mr. W. Topley,§ shows that no complex set of conditions are

* *Philosophical Transactions*, 1842, page 52.

† *Memoirs of the Geological Survey*, vol. ii., part 1, page 142.

‡ "The Geology of the South Staffordshire Coalfield." *Museum of Practical Geology and Geological Survey*, 1853, vol. 1, part ii., page 149 ; and *Manual of Geology*, third edition, page 214.

§ "Geology of the Weald," *Memoirs of the Geological Survey*, London, 1875, page 237, and illustrations on pages 59 and 238.

necessary to produce a "trough-fault," further than a fault intersected by a later second fracture, faulting the dislocated portion along with the strata, which it had already divided. Mr. Topley points out that it is possible that Prof. Jukes had overlooked the faulted portion of the original fault in the coal-fields described by him. In a foot-note he draws attention to the fact that Sir Joseph Prestwich had figured trough-faults in his "Memoir on the Geology of Coalbrook Dale,"* and described these disturbances as difficult to account for, and gives the same explanation as Prof. Jukes, but his sketch of the intersection of two faults, resulting in a trough, clearly shows a faulted fault, as suggested by Mr. Topley. It is therefore obvious that Sir Joseph Prestwich had dropped on the actual facts without realizing their physical importance.

Before leaving Mr. Topley's memoir, it is only just to his memory to quote the following paragraph :—"The slip of the fault has not always taken place in a vertical direction, but sometimes more nearly approaching the horizontal, that is to say, the beds have had a lateral as well as a vertical slip." He gives two examples, namely, at Hastings and Horsham. In both cases the vertical throw was to the north, and the lateral slip to the west, and the hade was 50 degrees from the vertical in the first and 60 degrees from the same in the second

In 1884, Mr. J. J. Harris Teall wrote a paper "On a Faulted Slate"† from Borrowdale, and briefly referred to the view of Messrs. Phillips, Jukes and Topley above described, mentioning that the present writer had informed him that similar slate occurs at Tilberthwaite, near Coniston. Several good examples of these, the writer deposited in the Museum of Practical Geology, in which nearly all the faults are reversed. Mr. Teall points out that, so far back as 1877, Mr. E. J. Hebert, then of the Geological Survey, pointed out‡ that reversed faults in these slates are more numerous than the ordinary type. Mr. Teall concludes his paper as follows :—"Of course, the importance which the reader will attach to the present instance will depend on the view he holds as to the extent to which the general principles of rock-deformation are illustrated by minute examples. For my own part, I must confess to a growing conviction that the essential points of both mountain and lowland stratigraphy, to borrow an expression used by Prof. Lapworth, may be frequently studied in hand-specimens."

* *Transactions of the Geological Society*, series 2, vol. v., page 454.

† *Geological Magazine*, 1884, new series, third decade, vol. i., page 1.

‡ *Geological Magazine*, 1877, new series, second decade, vol. iv., page 441.

Mr. Hebert concludes his paper above referred to by stating "that direct faults are indications of vertical pressure, and reversed faults of excessive horizontal or lateral pressure;" but, assuming the much simpler origin of the latter faults proposed by Mr. Topley, there is no reason to suppose that they were formed in the manner indicated by Mr. Hebert.

Prof. Lapworth, in his presidential address to section C, at the Edinburgh meeting of the British Association in 1892, points out in brief that anticline and syncline must be considered together, and ever united form a single crust-wave, the arch and its complementary trough constituting the tectonic, structural, or orographic unit, namely, the fold, the study of which, brilliantly inaugurated by Dr. Heim in his *Mechanismus der Gebirgsbildung*, supplies the clue to the discovery of the occult causes that lie at the source of those superficial irregularities which give to the face of our globe its variety, its beauty and its habitability.*

Reasoning back from mountain fold-movement as described by Mr. Rogers in the Alleghanies, Messrs. Lory and Favre in the Western Alps, Messrs. Heim and Baltzer in the Central Alps, Mr. Bertrand in Provence, Mr. De Margerie in Languedoc, Mr. Dutton and his colleagues in the Western States of America, Messrs. Peach and Horne and others in North Britain, Prof. Lapworth shows that a "mountain-fold in its simplest form as that of a bent rock-plate, composed of many layers which have been forced into two similar arc-like forms, the convexities of which are turned, the one upwards and the other downwards," and he illustrates this by taking a note-book an inch in thickness, with flexible covers, with parallel lines ruled across the edges of the leaves on the top of the book $\frac{1}{8}$ of an inch apart, and :—

exactly at right angles to the plane of the cover. Then holding the front edges loosely, press the book slowly from back and front into an S-like form until it can be pressed no further. As the wave grows it will be noticed that the cross lines which have been drawn on the upper edge of the book remain fairly parallel throughout the whole of the folding process, except in the central third of the book, where they arrange themselves into a beautiful sheaf-like form, showing how much the leaves of the book have sheared or slidden over each other in this central portion. It will also be seen that when the S is complete that the book has been forced into a third of its former breadth. It is clear that the wave, which the book now forms, must be regarded as made up of three sections, viz., a section forming the outside of the trough on the one side, a section forming the outside of the arch on the other, and a central or common section, which may be regarded either as uniting or dividing the other two.

* *Report*, 1892, page 695.

On this Prof. Lapworth amplifies—the geological arch has to be divided into a trough-limb, an arch-limb, and a middle limb, which may be regarded as a copula or septum, according as whether it is regarded as joining or separating. Prof. Lapworth states, "in our note-book experiment . . . . that in the trough-limb and the arch-limb, the leaves or layers undergo scarcely any change of relative position beyond taking on the growing curvature of the wave. But the layers in the central part, or septum, undergo sliding and shearing."

Since Prof. Lapworth has placed his views on record, shearing phenomena have been discovered all over the British Islands, even in the Tertiary clays of the Isle of Wight, in the South Wales coal-field, the softer portion of the Coal-measures have been flexed, folded, and even faulted, while the outlying massive Pennant Grit has been in no way interfered with.

In the North Staffordshire coal-field, numerous examples occur of thrust-planes; thus at the Sneyd colliery, Burslem, the writer is indebted to Mr. John Heath for calling his attention to the triplication of the Rough Seven-feet coal-seam in one vertical plane, the roof of the uppermost band and the floor of the lowermost band remaining constant, pointing to horizontal movement of the intervening coals only. (Fig. 1, Plate XV.) It is worthy of remark that the area to the north of the triplicated area towards the outcrop has first a duplicated coal-seam, then an area in which the coal is normal in thickness, but through pressure has been deprived of its hydrocarbons, and under the ring of the hammer lies a leaden-like inert mass, while still nearer the crop the Rough Seven-feet coal-seam is entirely absent, the roof resting upon the floor.

Similar facts have been brought to the writer's notice by Mr. E. B. Wain, at Whitfield colliery, where the Hollylane coal-seam is duplicated on the deep, and absent on the outcrop side. In both cases, the sandstone roofs contain very curious examples of "wild" or "heathen coal," more especially a spherulitic structure, the coal occurring in bean-shaped ovals, of onion-like structure. These are considered to belong to the "cone-in-cone" structure by the authorities at the Museum of Practical Geology, and the very beautiful specimens given to the writer by Mr. E. B. Wain are now there in the cone-in-cone case, but do not resemble any others from any part of the country.

A very marked instance of duplication also occurs in the Seven-feet Banbury coal-seam at Leycett colliery, where owing to thrust-planes two sets of men worked vertically beneath and above one another, without

being aware of it, in the same coal-seam. For this information the writer has to thank Mr. G. Hyslop, and for information on the Minnie pit, Apedale colliery, he has to thank Mr. Craig. Here, on the Cheshire dip, there is the strongest evidence of great horizontal thrusting, as the roof, fossils and underclays differ much in equivalent seams on the Cheshire side of the faults ranging with the anticlinal axis, which causes the Cheshire and Staffordshire dip from those on the Staffordshire side.

In a paper read before the Manchester Geological Society, on March 27th, 1877, the writer pointed out that the difference of vertical thickness between the same coal-seams in the same district, and occasionally in the same colliery, could only be accounted for by horizontal shifting, and the writer then pointed out that Section 62 of the Geological Survey, arranged by him to elucidate this point, showed an increase of vertical sedimentation towards the centre of the Wigan coal-field of 66 to 88 feet per mile traversed, and therefore a small vertical throw might be accompanied by a mile-long horizontal shift, necessitating from 66 to 88 feet greater vertical distance between two coal-seams in adjacent areas.

Another curious phenomenon in the North Staffordshire district is the occurrence of faults in depth, and not affecting the uppermost seams. A very good example of this at Bucknall was kindly communicated to the writer by Mr. Byrne, of the Chatterley-Whitfield collieries (Fig. 3, Plate XV.).

The slickensiding from thrust-planing is observable in the most intense degree in the Moss coal-seam at Sneyd colliery, and in every fibre of the coal-seam above described. The writer has to thank Mr. Allen Heath, as to evidence of similar facts at the Central collieries, Bucknall.

Joints, faults and mineral veins alike point to wide and long-continued horizontal movement.

The importance of studying joints and other divisional planes of rocks and the varied forms they assume, both when freshly exposed or when in various degrees modified by atmospheric influences, has been shown to be as important to the landscape-painter as the study of anatomy to the figure-painter by Mr. Ruskin in his own inimitable style in *Modern Painters*, vol. iv. And the late Sir Henry de la Beche, first Director of the Geological Survey, clearly showed the important factor that the natural direction and frequency of divisional planes have in determining the direction of our sea-coasts, and the rate at

which the coast is eroded by the action of the breakers.* Horizontal shearing, therefore, alike affects economic results as to coal and mineral veins, the direction of our coasts, and the picturesque nature of the surface of the country.

The PRESIDENT said that the largest horizontal thrust he knew in this district was at the Minnie pit, where the seam was bent in such a position that they could sink through the coal at two points. He should think that the thrust at the Sneyd colliery was a profitable one, inasmuch as it made three seams there whilst other collieries had to be satisfied with one seam.

Mr. JOHN HEATH said though they might have the coal three times over in one place, there were barren places to make up for it.

A vote of thanks was accorded to Mr. De Rance for his paper.

Mr. WILLIAM FREAKLEY read the following paper on "The Compounding of Colliery Winding-engines":—

* *Geological Observer.*

To illustrate Mr C. E. de Rance's Paper on "Horizontal Thrusting" etc.

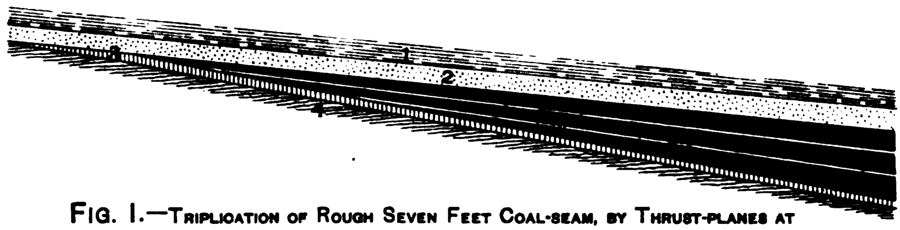


FIG. 1.—TRIPLICATION OF ROUGH SEVEN FEET COAL-SEAM, BY THRUST-PLANES AT SNEYD COLLIERY, BURSLEM, NORTH STAFFORDSHIRE.

REFERENCE.—1 AND 2. ROOF; 3, UNDER-CLAY; AND 4, SHALES.

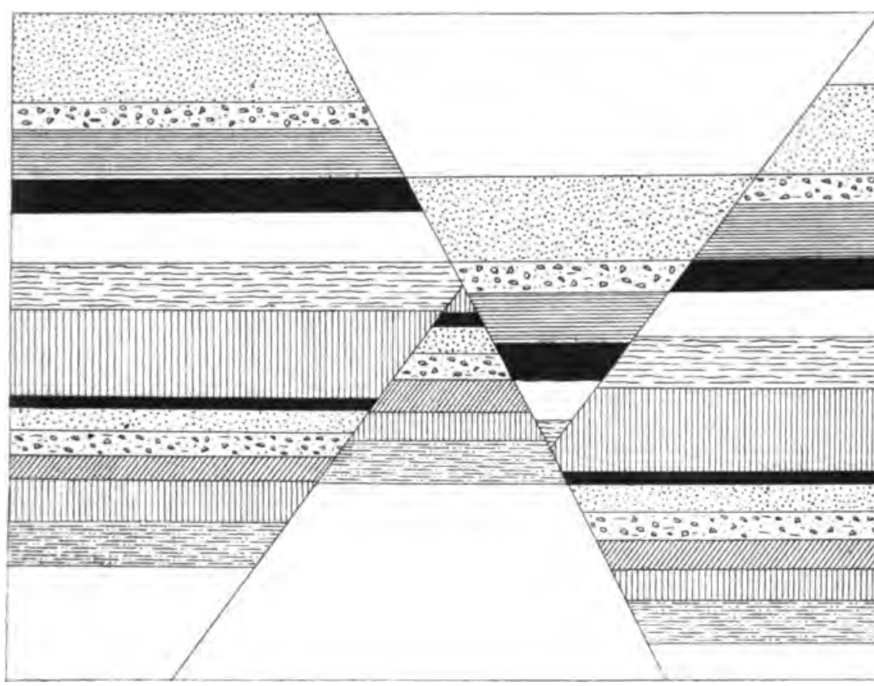


FIG. 2.—FAULTED FAULT.

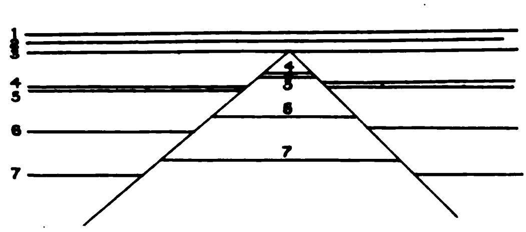


FIG. 3.—TROUGH-FAULTING PRODUCED BY FAULTED FAULTS: THE THREE UPPER COAL-SEAMS ARE NOT FAULTED.

THE COMPOUNDING OF COLLIERY WINDING-ENGINES.

By WM. FREAKLEY.

Much controversy has from time to time arisen as to the value or otherwise of the compounding system, when applied to intermittent winding-engines. The subject has not, however, so far as the writer is aware, received that degree of practical analysis which its importance justifies. In order to thoroughly understand relative values in this connexion, it is necessary to grasp the fact that what is good for a continuous-running engine is not necessarily good for one running intermittently.

The compound engine depends very much for its economy on the avoidance of extreme ranges of temperature in its cylinders, whereby condensation is much reduced, as also is the quantity of heat rejected by the engine. Take, for instance, a modern compound condensing-engine, running continuously, and driving a practically constant load. The steam would be cut-off in the high-pressure cylinder at about 0·25 of the piston's stroke, and in the low-pressure cylinder at about 0·375 of the stroke. The range of temperature in such an engine would be comparatively small, and the cylinder-condensation would be consequently low; but if the said engine be brought to a state of rest for a minute or two, it would take several minutes to re-establish the economic cycle above described.

Take now a compound condensing winding-engine. In order to start the load from the bottom of the shaft full steam is admitted to the high-pressure cylinders for fully 0·75 of the piston's stroke, until the speed is accelerated to the desired degree, when the steam is withdrawn by the regulator, or shut-off altogether, the run being completed by reason of the momentum acquired by the drums, ropes, cages and load, the brake determining generally the exact point of arrest. It will be seen that the greater portion of the winding is performed under negative conditions as far as the cylinders are concerned, during which time the temperature of their surfaces falls very considerably.

In some instances a very ingenious progressive cut-off mechanism has been applied to the high-pressure cylinders in order to cut off the

steam earlier for each revolution of the drum—the mechanism being brought into action after any desired number of revolutions have been made, and thrown out of gear at any determined part of the winding. Whichever method be used, it is evident that the conditions which are indispensable for the success and economy of a compound engine, are entirely absent so far as the high-pressure cylinders are concerned. What then may be the state of things in the low-pressure cylinders? When starting the load from the bottom, the low-pressure cylinders are surcharged with steam at a high terminal pressure from the high-pressure cylinders: the surfaces in contact with the steam becoming highly heated, until the load has attained the necessary velocity, when the steam is practically shut off, the remainder of the winding being performed under the worst possible conditions from an economical point of view. The fall of the cylinder-temperature is enormous, the refrigerating action of the condenser comes into play on the extensive surfaces of the low-pressure cylinders, pistons and passages, leading to excessive and disastrous condensation of the steam from the high-pressure cylinders at the next run.

A dispassionate consideration of the foregoing facts must point irresistibly to the conclusion that, for engines which have to be stopped and started every few minutes, and in which the greater portion of each run is performed under negative conditions, as before stated, the compound cycle cannot be successfully applied as far as steam economy is concerned. On the other hand, it is highly probable that a close scrutiny would reveal a considerable loss. Another drawback (and one upon which too much stress cannot be laid) in the case of winding-engines, is the encumbrance of the engine with much additional gear, which entails costs for lubrication and maintenance and renders the engine less handy to manipulate, while the excessive flooding of the cylinders constitutes an element of risk.

The writer's idea of a winding-engine is that of all stationary engines, it should be pre-eminently simple and easy to handle, anything involving additional risk being sternly excluded from its design, and thus give the engineman every opportunity of concentrating his attention on the primary element—safety of handling.

The writer's object in the present short paper is to deal in a general way with the cardinal points of a subject of primary importance to colliery-managers and engineers, and about which much misconception at present exists. On a future occasion he hopes to be able to submit facts and figures, together with indicator-diagrams, illustrative of the scientific

points involved. In the meantime he is of opinion that good would accrue if mining-engineers and colliery-managers, who have winding-engines in regular use, working on the compound system, would place before the members the results of their experiences, and they might lead to an intelligent discussion of the subject. The writer holds that in these days of economic management, no one responsible for the safe and economical working of colliery-machinery can afford to summarily neglect any circumstances which may affect the same.

The PRESIDENT (Mr. J. C. Cadman) said that the members had a good example of the system advocated by the writer of the paper at Sneyd colliery.

Mr. JOHN HEATH said that the winding-engines at Sneyd colliery were now working satisfactorily; they had had no trouble with them, and as regarded handling and reversing them, the engineman, by simply placing his finger on the handles, could work them. They did not even require grasping. They were working most economically (two boilers being saved), and there had been no mishaps with the condenser.

Mr. W. BAILES thought that the economy could best be proved by taking into consideration the evaporation from the boilers.

Mr. THOS. ASHWORTH moved a vote of thanks to Mr. Freakley for his paper.

Mr. HEATH seconded the proposition.

Mr. J. R. HAINES said that the saving of two boilers out of six by the use of a compound winding-engine was an important economy, not only having regard to the saving of the first cost of the boilers, but to the saving of fuel and stoking.

The resolution was carried unanimously, and Mr. FREAKLEY briefly replied.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW, FEBRUARY 8TH, 1899.

MR. JAMES T. FORGIE, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

Office-bearers for the session 1899-1900 were nominated.

The following gentleman was elected :—

MEMBER—

Mr. JAMES HENDERSON, P.O. Box 19, Salisbury, Rhodesia.

DISCUSSION ON MR. GEORGE L. KERR'S PAPER ON "TIMBERING AND SUPPORTING UNDERGROUND WORKINGS." *

Mr. J. M. RONALDSON (H.M. Inspector of Mines), referring to the tables given by Mr. Kerr in his paper, thought that it would have been more valuable had he stated the number of persons employed per person killed, instead of stating the percentage of persons killed by falls of roof. It was obvious that those percentages varied, not on account altogether of the number of accidents that took place, but as the other accidents varied in number. For instance, there might be a large explosion at a colliery during the year, killing 50 men. That fact altogether altered the percentage of the accidents, and he would suggest to Mr. Kerr that if he would make out a table giving the number of persons employed per life lost instead of the percentages, it would enhance the value of his paper. Referring to Table III., Mr. Kerr said "if we take the ratio of accidents to the number of tons of coal raised in each district, there is a very wide margin of difference for which it is difficult to account."† He thought that there was no difficulty in accounting for that difference,

* *Trans. Inst. M.E.*, vol. xvi., page 230. † *Ibid.*, page 231.

if they remembered that collieries and districts varied in the average quantity of coal wrought per man. Taking Scotland alone, according to Table II., the average percentage of deaths from falls was 48·8 in both districts. Looking at Table III., they saw that East Scotland seemed to be more favourably situated than West Scotland. He had not gone into the question, but he had not the slightest doubt that this was partly due to the output per man in East Scotland being much larger than in West Scotland. He endorsed what Mr. Kerr said* about the cause of these accidents by falls; and he would refer members to his own report for the year 1893 with reference to this point.† He was sorry to differ from their President, who seemed to blame the introduction of safety-lamps for the small diminution in the number of accidents from falls. At the first glance this seemed a reasonable opinion; but, unfortunately for this argument, facts were entirely against it. In England, in some of the large mining districts, this question had been thoroughly investigated, and also in Scotland, and the facts proved that, instead of the introduction or use of safety-lamps tending to prevent the diminution of such accidents, those pits into which safety-lamps were introduced had fewer accidents by falls than when naked lights were previously in use. He was certain that what he had said would be found to be the case in the Kilsyth pits, where some years ago safety-lamps were introduced. Again, in the discussion, Mr. Forgie said that he was not in favour of the deputy system of propping, as adopted in the North of England. For a long time he was of a similar opinion; and, no doubt, theoretically people would think that the men who were to suffer if an accident happened would be the men to look after their own safety. But in recent years he had changed his opinion, and he would like to see a trial made in Scotland of the deputy system. He was quite satisfied from his own experience that the miners did not look after their own safety as carefully as they ought, and if a regular system of setting the props by men appointed for the purpose were introduced, he believed that there would be a decrease in the number of accidents that took place from falls.

Mr. HENRY AITKEN (Falkirk) agreed with the President as to the propriety of men propping their own places, and he disagreed entirely with what Mr. Ronaldson had said. Independently of the argument that men could take better care of themselves than others would, it should

* *Trans. Inst. M.E.*, page 231.

† *Report of H.M. Inspectors of Mines for 1893, West Scotland*, page 7, after line 16.

not be forgotten that the deputies were not always on the spot when wanted, and if a man was not able to timber his place properly he should not be there. In his experience, the greatest mistake made in timbering, particularly in soft roofs and sides, was that allowance was not made for side weight. Gears were put in and jammed hard against the side, and, as a consequence, when side weight came on it broke them in the middle. At one colliery which he had inspected he ordered the gears to be put in with ample space at the ends, and these stood for many years.

Mr. RONALDSON asked whether the gears were set in the roads or at the working-face?

Mr. AITKEN replied that they were set in the main roads. With regard to the diminution of strength in timber treated by the Aitken process, he expected that Prof. Louis would make further experiments with timber treated by his process to determine what loss, if any, there was in the strength of treated timber and when dry. It was known that all timber when moistened with water or steeped in oil was softened and weakened, but there was almost no difference in the strength of the timber when re-dried, so far as he had tested. And they had to keep in view that, with ordinary mining-timber, it had to be used of two or three times the strength that would otherwise be necessary, in order to make up for loss of strength when it came to decay, a process which as a rule began at once. It was no great disadvantage if the treated wood was even 10 or 15 per cent. less strong, because untreated wood had always to be proportionably stronger, so as to allow for partial decay; whereas timber, treated by his process, never decayed, and it was not liable to burn like ordinary timber or timber treated with creosote, which rendered the timber most inflammable.

The PRESIDENT (Mr. J. T. Forgie) agreed with Mr. Ronaldson that in considering statistics of mining-accidents it was difficult to make true comparisons, and that Mr. Kerr in taking the percentage of accidents from falls of roof and sides in relation to the total accidents in mines for a number of years was not using the figures which best showed the march of progress or want of progress. The conditions in different mines and at different times varied, and while one colliery might, by taking the output of coal per life lost or person injured, compare very favourably with another colliery, the comparison might be very unfavourable if based on the number of persons employed per life lost or person injured. Statistics were often deceptive, and those contained in the annual reports of H.M. inspectors of mines, while the best and

most reliable, were not absolutely convincing on all points. With regard to the deputy system of propping miners' working-places in vogue in the North of England he was glad to hear that Mr. Aitken agreed with him. He was always of opinion that no man could possibly have a greater interest than the miner in keeping his place safe. He was constantly in his working-place, and had therefore the opportunity (which no deputy visiting the place at frequent intervals could possibly have) of noticing and hearing the change that was going on in the conditions of the roof and sides, and was, consequently, the best judge as to when and where support was most needed and would be of greatest advantage to secure his safety. He thought that this was an important factor in propping, and a prop put up in due time and in a suitable place would often be of greater service than several props put up by the deputy when he came round. Of course, there was always before them the fact that the ordinary miner was careless and indifferent as to his own safety, but he was not sure that the deputy system would mend matters, as the tendency would be for the workman to be more careless and to rely too much on the deputy to protect him.

Referring to safety-lamps, he would be the last man to condemn their introduction where found necessary, as he thought Mr. Ronaldson would be prepared to admit. Some years ago, when he was forced by arbitration, at Mr. Ronaldson's instigation, to introduce safety-lamps into many of the Kilsyth collieries, he was against it, but he was now quite prepared to admit that it was the right course, as the numerous small explosions of fire-damp and fires in the workings were now a thing of the past and the risks of large and disastrous explosions had been greatly reduced. At the last meeting he intended to say that, in their present unwieldy form and with their insufficient light, the safety-lamps now in use were not conducive to a diminution taking place in loss of life and injury resulting from falls of roof and sides. It was not reasonable to expect, and he did not think it was practicable to have work of any kind, and especially the work of securing the roof and sides of a mine, so well done with the meagre and insufficient light of a present-day safety-lamp, which, if tilted the least to the one side, went out, as with an open light, which gave an infinitely superior light, and that in all directions. Mr. Ronaldson stated that it had been the experience of H.M. inspectors of mines that, in some collieries in England and in Scotland, improvement had actually taken place in respect of accidents from falls of roofs and sides, since the introduction of safety-lamps. This could only, in his opinion, be a coincidence, as it was against common sense to expect better work

to be done in comparative darkness than in good light. Mr. Ronaldson asked whether this had not been his experience at the Kilsyth collieries since the introduction of safety-lamps. Well, the roofs there, except in one or two cases, were fairly good, and the accidents from falls of roof and sides were never very numerous; but he would be surprised if there had been any improvement due to the introduction of safety-lamps. During recent years, and especially since the introduction of legislation and the inspection of mines, there had been a great diminution in all classes of accidents, excepting in those resulting from falls of roof and sides; and he had no hesitation in saying that the introduction of an inferior light into mines (although it had undoubtedly greatly reduced the accidents from explosions of fire-damp) had stayed the march of progress in the accidents from falls of roof and sides. It was not to be understood that he advocated reverting to the use of open lights. They must maintain the improvement—and, if possible, increase it—that had been derived by the introduction of safety-lamps in one class of accident; and what he desired to see was the introduction of a better safety-lamp—either by an improved oil-lamp or by an electric lamp—and he saw some prospect of electrical engineers providing the miner with a light at least equal in every respect to the open light. He was inclined to the opinion that, by the use of a better light, greater reductions were to be looked for in the accidents from falls of roof and sides than by a general introduction of the deputy system, which, so far as he could see, had not met with any great success in the North of England, the only part of the United Kingdom where it had so far been introduced.

There was no necessity for the preservation of timber for use at the face, especially in longwall-workings. It might be of advantage to use preserved timber in haulage-roads and air-courses, where it was advisable to use timber of the best and most durable quality. He agreed with Mr. Aitken that timber was in nearly all cases used of much greater strength than was theoretically required to resist both transverse and crushing strains, in order to cover the loss of strength which would in course of time ensue from decay. Preservation of timber by creosote-oil certainly reduced it in strength and made it brittle, and this a dangerous method of preservation, from the risks of fire, was the only one of which he had experience. It was, however, a question of economy whether it was better to use stronger timber than that actually required, as mining engineers now do, and renew it from time to time; or to use timber of a cheaper quality, more proportionate to the strength required,

and treated at some expense with a preservative which would make it more durable.

Mr. G. L. KERR agreed with the President that it was difficult to make comparisons of statistics, and if Mr. Ronaldson had examined Table II. he would have seen that, as footnotes, he had given the percentage of persons killed by falls of roof and sides after the results of certain explosions had been omitted. The number of persons killed in proportion to the number of persons employed underground was published every year in the reports of H.M. inspectors of mines, and he had not repeated them in his paper.

Where the deputy system of timbering was adopted, practically the same percentage of accidents occurred as under the other system. Scotsmen were "canny," and never adopted anything until it had proved a success elsewhere, consequently until the deputy system was proved to be more satisfactory than when the propping was done by the collier it would not be wise to adopt it. He held that the collier was the best man to judge as to the condition of his working-place.

The discussion was adjourned.

Mr. ROBERT WEIR read the following paper on "The Douglas Coal-field, Lanarkshire":—

THE DOUGLAS COAL-FIELD, LANARKSHIRE.

By ROBERT WEIR.

Geographically, this coal-field lies within the parishes of Douglas, Lesmahagow and Carmichael, in the county of Lanark, and traverses in a north-easterly direction the Kennox and Douglas Waters for a distance of 10 miles, but seldom exceeds 1½ miles in breadth. Isolated as it is from the Lanarkshire coal-field proper, and situated some distance from a manufacturing or shipping centre, this field, perhaps, from a geological and commercial standpoint, has received comparatively little attention. A map of the district is shown in Fig. 1 (Plate XVI.).

Of the earlier mining operations in Douglasdale there are few records, but evidence is not wanting to show that consecutively for the last 200 years both coal and limestone have been wrought. Even yet, however, by far the greater area of the coal-field lies intact, and it is probable that until the beginning of this century only sufficient coal was wrought to meet a local demand, and for the calcining of such limestone as was mined in the district. Nevertheless, the quantity of coal yielded prior to 1800 must have been considerable. About this time, in the north-east or Ponfeigh and Rigside district, nearly the whole of the level-free coal and adjacent to the Douglas Water had been exhausted. At Glespin and Carmacoup, towards the opposite boundary, a similar state of circumstances had been attained. From then until the present time, excepting a small hill-sale colliery on the glebe-lands near Douglas village, mining has almost wholly been confined to the same localities, although abandoned workings are visible for nearly the whole stretch of the field along its southern outcrop.

In 1796, Mr. Alex. Scott, of Newbattle, was engaged by the then Lord Douglas to report on the working of the Rigside minerals, and it is clear from his report that the tacksman, who held leases on both the Rigside and Ponfeigh properties, was beginning to experience the disadvantages and expense attendant on the working and draining of coal inaccessible from adit-levels. This report of Mr. Scott's deals exhaustively with the nature and extent of the Rigside leasehold, and exhibits the disabilities under which the mining-engineer then laboured, as without district- or geological maps he noted his observations, collected his data, and arrived at his

conclusions. The report likewise sheds some interesting light on the conditions of labour then prevailing at the mines, and also the terms under which leases were held. The colliers were still the property of the landlords, in that neither they nor their families were at liberty to leave the soil without the consent of the landowners so long as mining was being carried on, and mention is made of the tacksman having for 7 years employed in the Ponfeigh mines 16 or 18 of Lord Douglas' colliers, and that in such a manner as to be inimical to his lordship's interests. The following excerpt shows the standard rate of wage then to have been 1s. per day, and that we have still with us the descendants of those worthy colliers :—" It is wellknown amongst coal-masters that it is ridiculous to engage colliers by the day. Notwithstanding of this Mr. Coventry [the lessee] paid at the rate of 1s. per day for the working of the coal, and it was candidly acknowledged to me that they did not work near so much as they would have done had they worked to be paid by the load." Even at that time the collier was not without his grievance, and reference is made to the practice of stacking separately each man's coal on the surface, "it thereby losing considerably in bulk and weight from exposure to the air," and payment only being made to the collier when his bing was sold. The selling-price of the coal was also fixed by the lease ; and as the Ponfeigh coal was sold at 1d. per load more than the Rigside or Douglas coal, and the workmen remunerated proportionately, Mr. Scott remarks, "No peace can be kept amongst colliers unless they all be upon equal footing."

He further suggested the use of steam pumping-machinery in order to more fully develop the Rigside mines, and a few years later along with the Ponfeigh leasehold they passed into the hands of Mr. Robert Swann, who then owned extensive collieries in the counties of Ayr and Lanark. He, acting on Mr. Scott's recommendation, first introduced steam pumping-engines into this locality, and with such success that for the next 50 years the Rigside mines were the chief source of supply for coal and limestone for the upper ward of Lanarkshire and the adjoining parishes in Peeblesshire. At Glespin, throughout the greater part of this period, the mines appear to have been wrought intermittently, and, after being exploited and abandoned by various tacksmen, they were also acquired by Mr. Swann, and still continue in the possession of this family. The extension of the Caledonian railway in 1849 into the southern counties had for a time a harmful effect on the mines of Douglasdale, but shortly after this Mr. James Swann discovered the celebrated Rigside cannel coal, and the development of this seam brought renewed prosperity

to the mines, although distant some 5 miles from the nearest railway-terminus to which this coal was carted. On the opening of the Lanark and Ayr railway which passes through part of the Douglas valley, access was obtained to the east and west coast markets and shipping-ports. This induced deeper sinkings and heavier fittings: at Rigside communication was obtained by an endless-rope haulage from the outlying shafts; and at Glespin, where the pits are 250 feet below the railway-level, an endless chain conveys the coal to the sidings, the gradient of the hutchway rising 1 in 3. Thus throughout the century Douglasdale has contributed more or less to the production of coal and limestone, but it is likely to effect a yet greater influence on the industrial life of Lanarkshire in the coming decade.

In 1850, Mr James Bryce contributed a paper to the British Association on the Lesmahagow and Douglas coal-fields, and he concluded that the coal-district of Scotland, extending from Ayrshire to Fifeshire, is but a single field, as nowhere do the older rocks on which the Coal-measures repose, attain a sufficient elevation to form independent basins. The Douglas coal-field he found to be an exception, but considered the coals to be of the same age as those of the Clyde basin, in that the coal-shales, ironstones, and sandstones contained a complete suite of fossils of true Carboniferous types. He also pointed out the importance of this coal-field to the south-eastern counties, and invited the attention of capitalists to its more thorough examination. In the explanation to Sheets 15 and 23 of the Geological Survey map of Scotland a description of the Douglas coal-field is given, but it omits much in the matter of detail, which it is hoped will be included in the long expected extended memoirs. The completeness and detail of the 6 inches maps of the district are however specially referred to by Sir Archibald Geikie in his subsequent works.

Confirming the opinion entertained by Mr. Bryce that the Douglas coal-field was dissociated from the Clyde valley coal-field, the following interesting paragraph occurs in the *Explanation of Sheet* 23 :—

From the data furnished . . . . it is evident that during the earlier part of the Carboniferous period, that area of the country in which the two groups of the Calciferous Sandstone series shown upon the map were deposited, had a singularly varied surface. The hills of Old Red Sandstone rose as uneven land from the southern margin of an inland sea or lake, which stretched over the site of what is now the Clyde coal-field. But this land formed merely a peninsula stretching westward from the southern uplands as far as the edge of what are now the plains of Ayrshire. It would seem also as if a hollow or water-basin existed even on this narrow peninsula, though possibly it may have been connected by one or more narrow passages with the main body of water which covered all the low grounds of

Ayrshire up to the base of the southern hills. This basin still remains in the cavity occupied by the Carboniferous rocks, from Lesmahagow by Douglas to the head of the Kennox Water. The hollows had been partly filled up by the deposition of the lower group of the Calciferous Sandstones, and had no other influence come into play than mere denudation and deposition, a great deal of the inequality of surface would doubtless have been removed before the deposition of the Carboniferous Limestone series. But there appears to have been a general subsidence of the whole area in progress, so that the long peninsula running from Tinto westwards into Ayrshire came gradually to be cut up into islands. Volcanic action also broke out in the west, and, filling up the bed of the lake or inland sea, formed that long bank of igneous material. . . . . By the subsidence of the district, each new deposit came to steal over the edges of those previously laid down, and to conceal them. In this way the Upper or Cement-stone group has overlapped the Lower or Red Sandstone group along the margin of the Kilncadzow and Hill Rig promontory, and south-westwards towards Lesmahagow; while both are in turn overlapped and concealed by the basement-beds of the Carboniferous Limestone series round the extreme southern edge of the Clyde basin, and again to the south of Lesmahagow. But traces remain of a much wider overlap and extension of the limestone-beds. On the very crest of the Old Red Sandstone ridge, to the south of Tinto, an outlier of the limestone occurs; another occupies a similar position 4 miles to the south-west. . . . From these facts, we see how the irregularities of the ancient land were one by one covered up by the Carboniferous deposits, which successively formed over them as they went down. This evidence has a further interest, inasmuch as it bears upon the former and much wider extension of Carboniferous rocks over the south of Scotland. As the deposition of the Carboniferous Limestone series went on, the subsidence continued with the same gradual overlapping of strata, until . . . the Coal-measures came to rest directly upon the Silurian rocks of the ancient subsiding land.*

In the Douglas coal-field all the great groups of the Carboniferous formation are represented, having doubtless escaped the re-excavating agency which removed the Carboniferous and Permian deposits from the southern Silurian hills, in descending order, namely:—Coal-measures, Millstone Grit, Carboniferous Limestone and Calciferous Sandstone. Beginning with the last or basement group, rocks of this period crop out in the Carmacoup and Kennox district. They also occupy a considerable area on the north and east of the field. Unless we include a concretionary corn-stone which probably represents the Camps limestone of Mid-Calder, no minerals of any value have been discovered, although it is in these strata that the Westwood and Houston coals and the oil-shales of the Lothians are present. It is possible that the Carboniferous Limestone series will be found throughout the coal-field. At Kennox Water, where it disappears under the Millstone Grit, and at Rigside, whence it appears from under the same formation, the series is particularly rich in coal and limestone. In the former locality, the strata are not so fully developed as at Rigside, and no workings or borings having been undertaken there, the position and quality of the seams, of which there are several,

* Page 22.

have not been determined. At Rigside and Ponfeigh, this group attains a thickness of nearly 1,800 feet. In the following section, the position of the several seams of coal and limestone is shown, and with the exception of the Castlecary or Gair limestone, which forms the upper horizon of the Carboniferous Limestone formation, it includes the complete group down to the Hurlet limestone :—

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Strata	74	9	74	9
2	Limestone, *Gill or Calmy*	3	11	78	8
3	Strata	16	0	94	8
4	**COAL**, *Gill Coal-seam*	7	2	101	10
5	Strata	143	0	244	10
6	Limestone, *Gas Coal*	2	2	247	0
7	Strata	4	5	251	5
	Gas Coal-seam —				
8	**COAL**, dross ... 2 ft. 5 in.				
9	Cannel ... 1 ft. 8 in.				
10	Stone ... 0 ft. 6 in.				
11	**COAL**, dross ... 1 ft. 6 in.				
		6	1	257	6
12	Strata	98	0	355	6
13	Limestone ...	4	0	359	6
14	Strata	38	0	397	6
15	**COAL**, foul ...	3	0	400	6
16	Strata	61	0	461	6
17	**COAL**, *Ellenora Coal-seam* ...	4	0	465	6
18	Strata	47	0	512	6
19	Limestone ...	2	0	514	6
20	Strata	62	0	576	6
21	Limestone, *Small-burns or Index*	5	0	581	6
22	Strata	68	0	649	6
23	**COAL**, *Nameless Coal-seam* ...	3	0	652	6
24	Strata	81	0	733	6
25	**COAL**, *Wee Drum Coal-seam*	4	0	737	6
26	Strata	6	0	743	6
27	**COAL**, *Big Drum Coal-seam* ...	7	0	750	6
28	Strata	20	0	770	6
29	**COAL**, *Skate-rough Coal-seam*	4	9	775	3
30	Strata	48	0	823	3
31	**COAL**, *Kirkroad Coal-seam* ...	5	0	828	3
32	Strata	30	0	858	3
33	**COAL**, *Stony Coal-seam* ...	4	6	862	9
34	Strata	109	0	971	9
35	**COAL**, *Back Coal-seam*	9	0	980	9
36	Strata	52	0	1,032	9
37	**COAL**, *Rob Coal-seam*	4	0	1,036	9
38	Strata	18	0	1,054	9
39	**COAL**, *Fallowhill Coal-seam* ...	4	0	1,058	9
40	Strata	365	0	1,423	9
41	**COAL**, *Wood Coal-seam* ...	2	0	1,425	9
42	Strata	195	0	1,620	9
43	Limestone, *Hosies or McDonald*...	3	0	1,623	9
44	Strata	2	0	1,625	9
45	**COAL**	2	0	1,627	9
46	Strata	70	0	1,697	9
47	Limestone, *Ponfeigh or Hurlet*	9	0	1,706	9
48	Strata	100	0	1,806	9
49	Limestone, *Wee* ..	3	0	1,809	9

There is no difficulty in identifying this section with the Muirkirk, Glenbuck, and Lesmahagow Carboniferous Limestone series, and correlating their contained limestones. The coals, on the other hand, are not so easily identified : still a few general characteristics are common to certain seams in each section. At Rigside, the dip of the strata is nearly due west, and from 1 in 1 at the outcrop decreases to 1 in 5 nearing the Douglas Water. This high inclination of the strata exposes in a comparatively limited area the whole section, and as the declivity of the surface is in the same direction as the dip of the strata, with a fall of about 200 feet in 1 mile, easy access was gained by the "ingoing-eyes," to

extensive stretches of coal, and this natural advantage has been fully embraced. It was only last year that a deep sinking and extensive plant were completed by the Coltness Iron Company, Limited, for the working of these coals towards the basin of the field. This colliery from its situation, equipment and appurtenances, should well nigh exhaust all the workable coal in the Limestone measures of the district, and the quantity of available coal should not be far short of 15,000,000 tons. The foregoing section, with the exception of the lower strata, was compiled by Mr. James Swann, the thickness indicating the seams at the outcrop. To the dip a distinctive thinning-out of the coals and strata is observed, and the working of several of the seams will be for the present unremunerative. As an example the Big Drum coal-seam which at the outcrop measures 7 feet of free-coal, 2½ feet of cannel, and 14 inches of ironstone, diminishes to about 4½ feet of coal, a few inches of cannel, and the complete elimination of the ironstone. Coincident with this decrease in the thickness of the coals they become more friable. The quality of the free-coal from all the seams is fairly uniform, and may be classed as second-rate, yielding coke in quantity and quality above the average. Than this coal no better is mined in Scotland for locomotive purposes, and it is from Rigside—now Douglas colliery, that the coal for many years has been selected to run the Royal train over the Caledonian system. Cannel is associated with nearly every coal, and it is of first-class quality, giving on an average 12,000 cubic feet of gas of 29·34 candle-power, and 1,170 lbs. of good coke per ton. The Gas coal-seam, near the top of the section, is perhaps the best in Scotland (Boghead alone excepted), the outcome in commercial practice being 11,732 cubic feet of gas of 35·31 candle-power per ton. The residual coke is 1,130 lbs. and very inferior. In a laboratory test with an exhauster much higher results were obtained. Both clay-band and black-band ironstones are found in the section. The ironstone underlying the Big Drum coal-seam and a black-band seam below the Skaterough coal-seam have been worked to a small extent, but neither can be regarded as of any value. Unless for agricultural purposes, the working of the limestones has been discontinued for over 20 years, but previous to this the Smallburns (Index limestone of Scotland) and Ponfeigh beds were largely quarried along their outcrops.

Coming to the Millstone Grit, extensive tracts of this particularly barren formation are exposed over the whole coal-field. Near Douglas railway-station a diamond-bore was recently put down, and cut through some thin coal-seams. This bore, and also one through the same strata about a mile farther west, are probably on the downthrow side of a

large fault, the existence of which may account for the Limestone coal-seams not being met with at what was considered an encouraging depth. In the Kennox Water, two workable coal-seams are visible, one 4½ feet thick, and the other 2½ feet; and at Springhill, near Douglas, a coal of some thickness, and near the same horizon as the 4½ feet seam, comes to the surface. Otherwise this series is unproductive, and no workings have been effected in any of the coal-seams.

The Coal-measures or Upper Series of the Carboniferous group occupy an area of about 5 square miles. From the explanation to the Geological Survey Map little information regarding the geology of this group is gleaned, further than that the Douglas Water traverses for 5 miles the middle of an elongated trough of rocks belonging to this series, that the Mussel-band ironstone forms an easily recognizable feature and crops out on each side of the trough, and that at Glespin the Upper or Red Sandstone group of the Coal-measures is seen.

The beds rising on each side of the valley form a syncline, having its axis parallel to the course of the Douglas Water in the same vertical plane, and from the extremities of the trough in which the strata lie nearly horizontal the Coal-measures gradually ascend and are replaced by the Millstone Grit. The following is the succession, in descending order, of the coal-seams in Glespin and Kennox Waters. From the Black-band ironstone to the Nine-feet coal is the actual section in No. 1 shaft at Glespin, and continued by a bore to the Carmacoup coal-seam. In other respects, the section is compiled from observation.

No.	Description of Strata.	Ft.	In.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	**COAL** ...	1	3				
2	Stone ...	2	0				
3	**COAL** ...	1	6				
				4	9	4	9
4	Strata			148	0	152	9
5	Ironstone, *Blackband*			0	4	153	1
6	Strata			60	0	213	1
7	**COAL**, *Seven-feet Coal-seam*... ...			7	0	220	1
8	Strata			66	0	286	1
9	Ironstone, *Mussel-band*			0	6	286	7
10	Strata			7	0	293	7
	Three-feet Coal-seam—						
11	**COAL** ...	3	0				
12	Stone ..	2	0				
13	**COAL** ...	1	6				
				6	6	300	1
14	Strata			59	9	359	10
	Four-feet Coal-seam—						
15	**COAL** ...	2	4				
16	Clay ...	0	5				
17	**COAL** .	2	0				
				4	9	364	7
18	Strata			93	0	457	7
19	**COAL**, *Nine Feet Coal-seam*... ...			9	0	466	7
20	Strata			42	0	508	7
21	**COAL**			1	2	509	9
22	Strata			12	0	521	9
23	**COAL**			2	7	524	4
24	Strata			44	0	568	4
25	**COAL**, *Carmacoup Coal-seam*... ...			4	0	572	4
26	Strata			30	0	602	4
27	**COAL** ...	0	10				
28	Cannel ...	0	4				
29	**COAL** ...	0	10				
				2	0	604	4
30	Strata			24	0	628	4
31	Ironstone, *Mussel or Shelly*			0	3	628	7
32	Strata			15	0	643	7
	Shale, position of *Slaty-band* ironstone —						
33	Strata			90	0	733	7
34	**COAL**, *Kennox Coal-seam*			4	6	738	1

The formation down to the Nine-feet coal-seam has an obvious resemblance to that underlying the Blackband ironstone of the Airdrie district. Above the Four-feet coal-seam are several beds of red sandstone and red fakes, and doubt here arises as to whether the strata may not belong to the Upper Coal-measures. In the Faskine district, a black-band and mussel-band ironstone overlie the Lanarkshire Ell coal-seam, but from the position and thickness of the beds a correlation is not discernible, and the colouring constituent of the sandstone and fakes may be accounted for by the proximity of the Old Red Sandstone hills. The lower part of the section bears a likeness to the basement series of the Dalmellington coal-measures. In identifying the various coal-seams of the Carboniferous strata of the different districts of Scotland, the officers of the Geological Survey have provided material valuable for general research ; but much remains yet for the geologist and mining-engineer to accomplish. From a reference to the *Transactions* of this Institution the correlation of the seams of the Ayrshire and Lanarkshire coal-fields may still be regarded as an open question, and the key to a thorough identification may lie through the Douglas field, unless (as already suggested) the latter is separate from and only contemporaneous with the former. The weight of evidence seems to favour the opinion that the Seven-feet and Nine-feet coal-seams are respectively the Virtuewell and Lower Drumgray, and in the list of fossils appended to the *Explanation of Sheet* 23 of the Geological Survey map, and from which are deduced the relative horizons of the more distinctive beds, the Nine-feet coal would appear to correspond to the Lower Drumgray or Shotts Furnace coal. These two seams fully maintain the thickness which their names imply, and they are of a uniformly superior quality. About 2 feet from the top of the Nine-feet coal, there is a hard splint-rib 3 inches thick, inclining at places to a cannel. Separated from this rib a 3 tons charge of equal proportions of the seams analysed out as follows :—

		Per Cent.
Volatile matter, containing 0·20 per cent. of sulphur ...		30·11
Coke—Carbon	60·00	
Sulphur	0·16	
Ash	1·50	
		61·66
Water expelled at 212° Fahr.		8·23

COKE.

Carbon	97·31
Sulphur	0·26
Ash	2·43

One ton of coal yields 12·3 cwts. of coke of excellent quality.

Recently, the Three-feet and Four-feet seams have been opened up. The former is a first-rate splint with a difficult roof, but the Four-feet, as also the other seams of the section, are of indifferent quality. Except in the vicinity of Glespin and at the Glebe colliery near Douglas village, through the exclusiveness of the landlord, no attempt has been made to prove at least 3 square miles of the Coal-measures, which probably contain 100,000,000 tons of workable coal.

Glespin colliery is situated at the south-western extremity of the trough, and within a short distance of where the Coal-measures begin to rise, terminating the syncline and forming a basin. The rise of the strata is from 1 in 5 near the centre of the basin, to 1 in 3 at the surface. The beds on each side of the trough are highly inclined, and at the Glebe dip 1 in 1½, tending to horizontality towards the axis of the syncline. In the Red or Upper Coal-measures near Glespin, a seam of coal has been opencast at the outcrop for a distance of nearly 900 feet. Here the strata lie nearly vertical, and a coal 2 feet thick is visible, but it scarcely represents the surface-disturbance caused by the opencast work, and the existence of another seam surmised. A fault, throwing down the Red measures, terminates the working of the Glespin coals to the north, and before this was fully realized it occasioned not a little conjecture and experiment.

Fig. 2 (Plate XVI.) shows a horizontal section of the formation through the fault. At some period, the Upper or Red measures may have conformably overlain the Coal-measures, and both groups of rocks in regular sequence seem to have overlapped the Old Red Sandstone. This would account for the absence of the Millstone Grit and the Carboniferous Limestone. When the subsidence in the direction from *A* to *B* took place, causing the tilting of the Upper or Red Measures, it would leave the cavity now filled with clay. A mine was cut from *C* to *D* and passed through a succession of soft red and green clay, which had the appearance at places of being regularly stratified; but they were probably washed down from the higher strata in the neighbourhood, to which their composition corresponds. At *D*, the mine passed into a post of hard red sandstone, and if the vertical displacement does not exceed the thickness of the Coal-measures, by continuing the mine, they may be found resting directly on the Old Red Sandstone at the overlap.

From the map, Fig. I, it will be seen that the field is intersected by dykes and faults. Two principal dykes of volcanic origin cross the district from the north-west. Parallel to these, and of the same nature, but of much less extent, run several others. The volcanic dykes of dark blue

or black crystalline basalt cut across all the other rocks up to the drift series, and even cross large faults without sensible deflection. In the Muirkirk coal-field one of these dykes traverses two volcanic vents, probably of the Permian age. This shows that those crossing the Douglas coal-field are much younger, and they are possibly of Miocene age. In the working of the coals none of these dykes have been encountered. Two strike-faults, letting down the Old Red Sandstone, bound the opposite longitudinal sides of the field. Where such faults occur the displacement is generally considerable, but dip-faults are the more prevalent and of less magnitude.

In the development of the mines or in the prosecuting of the workings no insuperable difficulties have been encountered. The strata are not heavily watered, compared with other fields having a high angle of dip, and where the beds have an extensive surface-exposure. The maximum quantity of water raised at Rigside was 1,400 gallons per minute, and at Glespin 600 gallons.

The chief source of inflow is from the wastes of the crop-workings, and is naturally affected by the rainfall. To counteract this evil, a judicious draining and trenching of the surface, and the cradling of the water-courses is necessary. None of the coals is liable to spontaneous combustion, and the mines are particularly free from noxious gases. Only once in 10 years has fire-damp been found at Glespin. On the morning of December 17th, 1896, a distinct explosion took place in the Four-feet coal-seam, and was felt throughout the workings, but happily unattended by any accident. As bearing on a controversy now exercising the minds of some experts, it may be of interest to state that, on the night preceding the explosion a seismic disturbance was recorded over the greater part of England and Scotland. The place in which the fire-damp was ignited had been standing for several weeks on an 18 feet upthrow, but was examined each day by the fireman with an open lamp, and as he had never previously encountered fire-damp in Glespin he was more astonished than alarmed. Whether the circumstance points to a pure coincidence, or the emission of gas as directly due to the disturbance, the fault offering a line of least resistance to its effects, may be left to the consideration of experts.

The physical aspect of the coal-field will demand close attention in the complete extraction of the coals. The working of the seams in the Limestone measures, where the thinning out of the intervening beds takes place, and the high inclination of the strata on each side of the trough present more than ordinary difficulties. The Douglas Water of itself,

flowing in a sinuous course along the Coal-measures, will offer a formidable disability, as the valley is very level and has an alluvial subsoil.

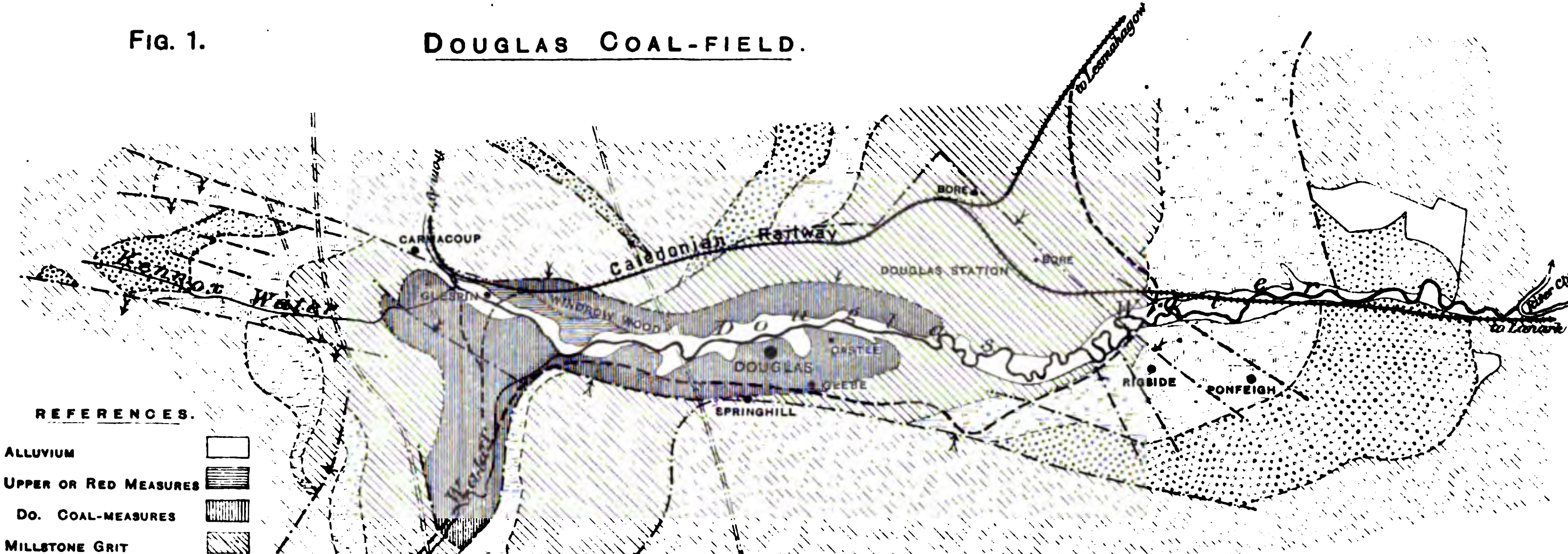
The great drawback to the opening up of the coal-field is the want of railway-communication. At Douglas station, the present Ayr and Lanark branch makes a detour away from the valley to avoid the policies of Douglas Castle, and does not again descend to the level of the river within the Carboniferous zone. The Caledonian Railway Company are now projecting a series of railways which will be of immense advantage to Douglasdale, and if constructed cannot fail to bring about the benefits pointed out by Mr. L. Bryce in 1850 as likely to accrue to the community of the south of Scotland from the extended development of the Douglas coal-field.

Mr. THOMAS H. BARR read the following paper on "Two Types of Electrical Coal-cutters":—

To illustrate Mr. Robert Weir's Paper on "The Douglas Coal-field, Lanarkshire".

FIG. 1.

DOUGLAS COAL-FIELD.

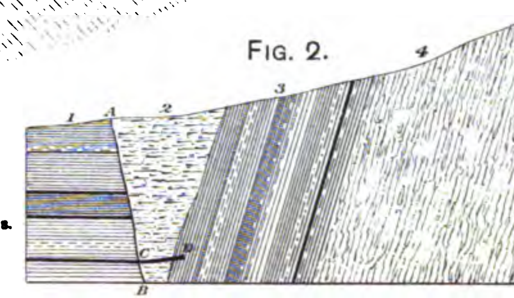


REFERENCES.

- ALLUVIUM
- UPPER OR RED MEASURES
- DO. COAL-MEASURES
- MILLSTONE GRIT
- CARBONIFEROUS LIMESTONE
- CALCIFEROUS SANDSTONE
- OLD RED SANDSTONE
- SILURIAN
- FAULTS (DOWN)
- IGNEOUS DYKES
- RAILWAYS
- PROPOSED RAILWAYS

Scale, 1 Mile to $\frac{3}{8}$ Inch.

FIG. 2.



REFERENCES.

1.—COAL-MEASURES.
2.—INFILTRATED CLAY.
3.—UPPER COAL-MEASURES.
4.—OLD RED SANDSTONE.

Andw Reid & Compy Ltd Newcastle on Tyne

TWO TYPES OF ELECTRICAL COAL-CUTTERS.

BY THOMAS H. BARR.

It might be asked why, with so great a choice of coal-cutters, the writer should have taken up only two, but one reason is that the paper deals exclusively with mechanical coal-cutters of which electricity is the motive power, as coal-cutters driven by compressed air have been successfully demonstrated, but by electricity the demonstration has not been so successful, especially in Scotland. Another reason is that

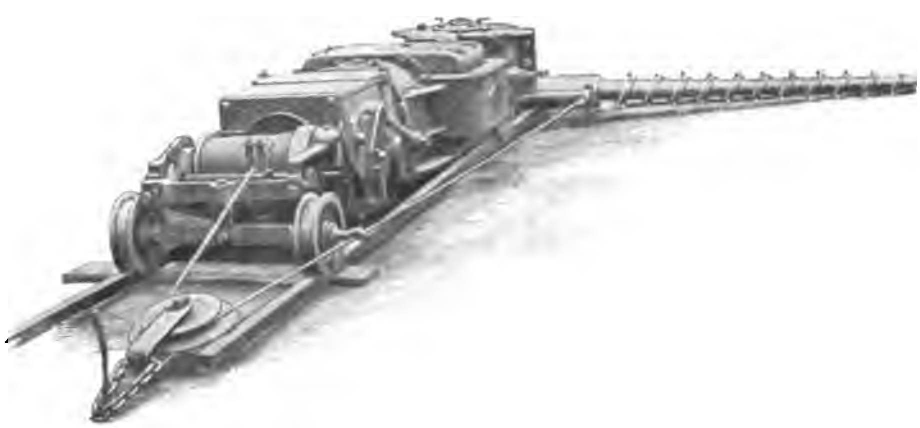


FIG. 1.—HURD COAL-CUTTING MACHINE—CUTTING IN FLOOR.

the two types of cutters are not only mechanically different, but were also at one time electrically different.

Hurd Coal-cutting Machine.—This machine consists essentially of three parts, (*a*) the motor, (*b*) the cutting-gear, and (*c*) the hauling-gear (Fig. 1).

The motor, which forms the main frame of the machine, is of 18 electric horsepower, series-wound, and fitted with either a drum or Gramme armature, preferably the latter. The field-coils are carried in brass boxes, which extend to the bearings at each end of the motor.

A brass cover is fitted over each end of the armature, entirely enclosing the motor, making it gas-proof, and protecting it from external damage and from dust or dirt. Carbon brushes are used, and they require very little attention, running for several months without any adjustment being necessary, and without in any way damaging or appreciably wearing the commutator.

The starting switch and resistance are carried in a rectangular box, fitted at the front or commutator-end of the motor-frame. All connexions between the switch and motor are made internally, and out of harm's way, the only electrical part exposed to view or risk of damage being the trailing-cables to the machine.

The cutter-bar and bearings are fitted in a separate casting or turn-table, which is carried underneath the gear-case in such a manner

FIG. 2.—HURD COAL-CUTTING MACHINE—CUTTING IN ROOF.

that it can turn round from one side to the other without the driving-wheels going out of gear, the object of this arrangement being (*a*) to give facilities for examination and changing of the cutters ; (*b*) to make the machine either right or left-handed; and (*c*) to cut into the face direct when required, without the necessity of first cutting a jib-hole by hand-labour.

The gear-case carries the bevel-gear wheels (4 in number) and the end-bearings for the armature-shaft. Instead of being permanently bolted to the motor-frame, this casting is arranged to turn round about the motor-shaft, and the motor-frame is made with a tubular end to receive it. The whole of the cutting-gear can, therefore, be tilted or turned upside down if necessary. If turned upside down, the cutter-bar is brought to the top instead of the bottom, and the holing can be done in this position equally as well as at the bottom of the seam, and at either the right or left-hand side as before (Fig. 2). Any

intermediate part can also be operated upon by suitably adjusting the back-wheels, which are provided with adjusting-screws and slides for raising or lowering the machine.

For collieries which work several seams with different conditions of holing, the writer thinks that one pattern of machine is all that is necessary, as by the arrangements just described the machine will cut pactically in any required position.

The rectangular box carrying the switch and resistance also contains a tool-box, the armature-shaft bearing and the worm and worm-wheel of the haulage-gear. The worm is fixed at the end of the armature-shaft and the worm-wheel is connected by a shaft with a slotted disc, to which the haulage-gear connecting-rod is coupled. The worm and wheel are run in oil. The actual haulage-gear is of the ordinary pawl-and-ratchet-wheel type with the addition of a cam-plate acting upon the driving-pawl so as to regulate the number of teeth that it engages, and consequently the travelling-speed of the machine can be regulated instantly without stopping the motor.

In connexion with the haulage-rope, a self-acting coiling arrangement is fitted ; this entirely does away with the setting of props ahead of the machine, and other manipulations adopted to lead the rope evenly upon the drum.

The machine is constructed to stand the rough usage of a mine. There is no bridle in front, the haulage-rope being attached direct to the cutter-bar sleeve, and there are no arrangements for keeping the machine on the rails, its steadiness when at work rendering any such provisions unnecessary.

Two of these machines have been at work for nearly 2 years in a mine in Staffordshire. Each weighs about 30 cwts., is 16 inches high, 30 inches wide, and 9 feet long. It undercuts to a depth of 3½ feet on an average, at a rate varying from 1½ to 2 feet per minute. The average cutting-speed is 2 feet per minute ; counting stops, it is 72 feet per hour and (taking in the whole time of machinemen from bank to bank, say, from 4 p.m. to 2 a.m), gives an average of 330 feet per 10 hours' shift. A start is usually made about 7 p.m., and the cut is finished by 12·30 midnight, the total time taken on the 20 cuts averaging, after 1 hour is deducted for meals, 4 hours and 36 minutes for the total cut of 330 feet.

Clarke Electric Coal-cutting Machine.—The coal-cutter is made entirely of steel, the frames being of H pattern. The motor, which is of

the ironclad type and of 23 electric horsepower, is bolted direct on the frame. To the end of the motor-shaft is connected a bevel-wheel, which gears into the cross-shaft; this is again geared into the second-motion shaft, the bevel-wheel of which works directly into the cutting-disc (Fig. 3).

The haulage-gear is of the usual type, worked by a crank-and-ratchet wheel from the first-motion shaft.

The starting-gear and resistance for the motor is also placed in a gastight case and so arranged that only one motion at the handle is needed to start or stop the motor.

While the motor is made of 23 horse-power, it is capable of standing double this power, which it is often called upon to do when cutting through hard parts, balls, etc. The amount of power required depends upon the class of holing and the depth of cut, and may vary normally from 12 to 20 horsepower.

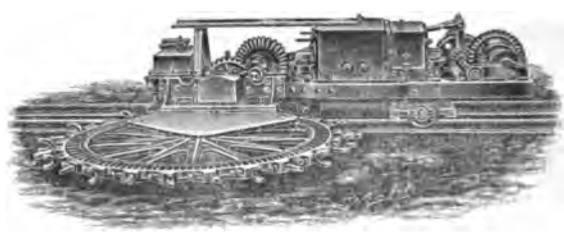


FIG. 3. - CLARKE ELECTRIC COAL-CUTTING MACHINE.

The depth to which holing can be cut depends upon many conditions, but the machine is at work with discs $5\frac{1}{4}$ feet in diameter.

The total weight of the machine is about 38 cwts. when fitted with a 3 feet cutting-disc. The cutting-disc is made of steel and in one piece up to 5 feet in diameter. Where there are no difficulties in the way, it is better to keep the cutting-disc in one piece, as several inconveniences arise when it is constructed in halves.

The cutters are so arranged that they can be instantly taken out and replaced. The most satisfactory results are obtained when the machine is slightly tilted, in which case it will cut on the floor-level which, however, requires a little levelling before the next road is laid.

In conclusion, so much has been written and printed in the *Transactions* on the relative cost of work by hand, compressed air and electric power that the writer has refrained from entering into this portion of the subject.

At Fauldhouse colliery, in Scotland, a coal-cutter has been working

for 3 years, and cuts 450 feet per shift of 9 hours. The seam is 22 inches thick, and a length of 450 feet by 2¾ feet of undercutting gives about 70 tons per shift: the difference in cost between mechanical and manual labour being about 6d. per ton.

If the undercut is to be as deep as, say, 4½ to 6 feet, made either by the disc or by the bar, then the machine must naturally be very much heavier than a coal-cutter holing to a depth of only 3 feet. In English mines, the deep undercut of from 4½ to 6 feet working about 240 feet per shift, is preferred to the light machine working on an average 400 to 450 feet per shift, with a cut of about 3 feet in depth.

In Scottish coal-mines, as a rule, the conditions are such that the lesser undercut finds most favour, and consequently lighter machines will be used. Indeed, it may be seen at a glance that when we speak of machines undercutting to depths of from 4½ to 6 feet, which is general in England, the conditions of mining are much more favourable for mechanical cutting than in Scotland. In England, the exceptionally good roofs allow the greater undercut, and heavier coal-cutters can therefore be used with advantage. But in Scotland, the conditions are somewhat different, as so many of the mines have bad roofs, and thus the same advantages would not be found from deep holing. Lighter coal-cutters with a greater length of holing are therefore preferred.

Within the last few years vast improvements have taken place in coal-cutters, one of the most important in the case of disc-machines being the tool-holders, which enable a set of 30 cutters to be changed in about 5 minutes, and have removed the possibility of cutters becoming loose or broken when at work.

The writer has refrained from giving any expression of opinion as to the relative advantages of one type of coal-cutter over the other; as, while describing two types, the object of this paper is to endeavour to promote a discussion on electrical coal-cutters in general, and not on one particular type. At the same time, it is a mistake to imagine that one type of machine can be made to suit all mines alike. Indeed, it is not sufficiently recognized that the conditions of working are too varied and changing, that the materials which have to be cut in different seams, and even in different parts of the same seam, differ too much in hardness and other characteristics, to make it probable that one kind of coal-cutter can be made applicable to them all. If machines are to be generally adopted, all the parts, as far as possible, should be duplicated, and thus no time would be lost in replacing broken parts.

The mine also should be laid out so as to allow the most to be got out of the machines. This could not be well done in troubled coal-fields.

There can be no doubt that an impetus was given some few years ago to coal-cutting by electricity in Scotland, and that it was checked was somewhat the fault of the makers of coal-cutters, who did not sufficiently recognize the varying conditions of mining, and led the coal-owners to expect more than they could possibly fulfil. On the other hand, the coal-owners themselves, failing to recognize the saving which electrically-driven coal-cutters would inaugurate with thin seams, may have possibly contributed to this by laying down conditions which made failure almost inevitable. But the experience of the last few years has made it evident to both, under what conditions electric coal-cutters can be and are being introduced and successfully wrought in thin seams.

It is not so much an electrical as a mining question. After studying it for a number of years the writer is of opinion that, where the physical conditions of any mine are favourable to mechanical cutting, electricity might with advantage be employed as the motive power. Certainly more skill is required in working it than with any other form of mechanical power, as, for instance, compressed air; but the cost of electric power being less, will in these times of keen competition cause it to be more generally adopted.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT MASON UNIVERSITY COLLEGE, BIRMINGHAM, OCTOBER 17TH, 1898.

MR. R. S. WILLIAMSON, RETIRING PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of Council Meetings were read and confirmed.

The SECRETARY read the Annual Report of the Council as follows :—

ANNUAL REPORT OF THE COUNCIL.

The Council are pleased to record that the Institute has again increased its membership, and that there are now 172 members upon the books, as compared with 161 last year.

There have been four general meetings and five Council meetings held throughout the year, and the following papers have been read :—

"Kynite." By Mr. William Cullen.

"Irish Legislation on Mining and Coal before the year 1800." By Mr. H. G. Graves.

It is to be regretted that more interest is not taken in the meetings, and that members do not come forward to read papers or introduce subjects for discussion. This is a matter which is troubling the local Institutes generally, and the reason no doubt is that the best papers naturally gravitate to the more important meetings of The Institution of Mining Engineers.

Upon referring to the accounts of your Institute, it will be found that the bank balance is £373 13s. 5d , which is £33 16s. 11d. less than last year, and this is due to the much increased payments to The Institution of Mining Engineers, and to the fact that fewer members have paid up their subscriptions; the arrears are consequently greater, yet the balance-sheet shows an improvement in your position, and a credit of £454 15s. 7d.

The Institute continues upon the list of Corresponding Societies of the British Association for the Advancement of Science and receives the Report of its *Proceedings* together with the *Transactions* of the leading British and foreign societies connected with mining.

As foreshadowed in last year's report, the name of The Federated Institution of Mining Engineers has now been altered to that of "The Institution of Mining Engineers."

There are 2,509 members, and 749 papers of a high standard upon various subjects connected with mining have been printed in the *Transactions*. General Meetings have been held in Scotland, Newcastle-upon-Tyne and London, and a Students' Meeting in Newcastle upon-Tyne. The Council for some time discussed the advisability of constituting a class of Fellows, but this has been abandoned, your Council thinks very wisely.

The annual meeting of The Institution of Mining Engineers was held in this district last month, and although it was held after the close of the financial year, still, as it is past, it is fair to record here that it was successful, and judging from the many letters and expressions of thanks received from prominent officials the meeting and excursions were highly appreciated and enjoyed.

Your thanks are again due and are hereby tendered to the authorities of Mason University College for providing rooms for the meetings.

The Council have again to strongly urge all connected with the Institute to use their best endeavours for its advancement, by reading papers and introducing new members.

Mr. R. S. Williamson, in moving the adoption of the report, said that it was satisfactory.

Mr. W. J. Hayward seconded the motion, and it was adopted.

ELECTION OF OFFICERS 1898-99.

The Scrutineers reported that the following officers had been elected for the ensuing year :—

President.—Mr. James Lindop, Bloxwich.

Vice-President.—Mr. G. C. Robinson, Brereton.

Council:

Mr. Nöel Chandler, Hednesford.

Mr. A. W. Grazebrook, Dudley.

Mr. T. G. Marsh, Dudley.

Mr. F. G. Meachem, Hamstead,

Dr. THE TREASURER IN ACCOUNT WITH THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS, FOR THE YEAR ENDING JULY 31ST, 1898. **Cr.**

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance in Bank ...	407	10	4	By Calls paid to The Institution of Mining Engineers, 1897-98 ...	111	8	3
,, Subscriptions received ...	195	19	6	,, Do. do. for Arrears of 1896-97 ..	47	12	0
,, Sale of *Transactions* ...	1	2	2	,, Secretary's and Reporter's Salaries ...	50	0	0
,, Bank Interest ...	6	3	7	,, Rent, Rates, Gas, etc., for Institute Room ...	20	0	0
,, Balance of The Institution of Mining Engineers' Meeting Fund, for Expenses ...	6	18	0	,, Expenses of attending Meetings of The Institution of Mining Engineers and of Audit ...	2	9	0
				,, Stamps, Parcels, and Telegrams ...	4	3	5
				,, J. Goodman & Sons: Printing Membership Lists, Circulars, etc. ...	6	10	0
				,, Richard Jones: Printing ...	0	17	6
				,, Caretaker at Mason University College ...	1	0	0
				,, Balance in Bank ...	373	13	5
	£617	13	7		£617	13	7

BALANCE-SHEET, 1897-98.

Liabilities.	£	s.	d.	Assets.	£	s.	d.
To The Institution of Mining Engineers ...	25	9	4	By Balance in Bank ...	373	13	5
,, Balance ...	454	15	7	,, Subscriptions due ...	106	11	6
	£480	4	11		£480	4	11

Examined and found correct,

October 17th, 1898. DANIEL ROGERS, WILLIAM H. WHITEHOUSE, *Auditors.*

This is exclusive of considerably more than £100 worth of property, for which no credit is taken.

Mr. W. B. SCOTT (H.M. Inspector of Mines), in proposing a vote of thanks to the retiring President (Mr. R. S. Williamson) and the officers of the Institute for their services during the past year, undertook that duty with pleasure because of his knowledge of Mr. Williamson as a friend, as a mining engineer, and as President of their Institute. The members would all agree that the retiring President had maintained the traditions of the office. He was a gentleman of scientific attainments, and had shown a most willing disposition to afford any information of interest to the members. The officers had carried out their duties in a manner deserving hearty recognition.

Mr. W. H. WHITEHOUSE seconded the motion, and it was cordially approved.

Mr. R. S. WILLIAMSON, in replying, said that he appreciated the kind manner in which the resolution had been proposed and passed. He had occupied the chair for the past 2 years, and he regretted very much that the gentleman (Mr. W. H. Whitehouse) who was elected last year could not, through illness, accept the office. He was pleased that he was to be succeeded by Mr. James Lindop, who, he was sure, would do credit to the position. The recent visit of the members of The Institution of Mining Engineers had given every satisfaction, and it only remained for him to make commendable reference to the excellent manner in which the arrangements were carried out by Mr. Alexander Smith, their esteemed Secretary.

The following gentlemen were elected :—

MEMBER—

Mr. HENRY FRANCIS OLDS, Mining Engineer, St. Just.

STUDENT—

Mr. W. E. SHARE, Walsall.

Mr. F. G. MEACHEM read the following paper by Dr. Haldane and himself on "Observations on the Relation of Underground Temperature and Spontaneous Fires in the Coal to Oxidation," etc.

OBSERVATIONS ON THE RELATION OF UNDERGROUND TEMPERATURE AND SPONTANEOUS FIRES IN THE COAL TO OXIDATION AND TO THE CAUSES WHICH FAVOUR IT.

By JOHN S. HALDANE, M.D., F.R.S., and F. G. MEACHEM, M.Inst.M.E.

The investigations described below originated in a discussion on observations communicated in two papers read before the Birmingham meeting of The Institution of Mining Engineers in 1895. In the first of these papers* it was shown that the natural temperature of the Thick coal-seam worked at Hamstead colliery is very considerably below that of the working-places and return air-roads: and in the second paper,† evidence was brought forward showing that ordinary black-damp is nothing but the residual gas left on the slow oxidation of some substance in the coal or in the neighbouring strata, and that as return air always contains a considerable amount of black-damp, oxidation on a very large scale is constantly occurring throughout the workings of a colliery. This oxidation might cause a rise in the temperature of the working-places and roads above the natural temperature of the strata; and as the question whether it actually does so is not only of scientific interest, but also of great practical importance in connexion with the possibilities of deep mining and the prevention of underground fires, the writers determined to investigate the whole matter further so far as their somewhat limited time and opportunities permitted. The results obtained are still far from complete, but they are published now in the hope that others may co-operate in the investigation.

The Thick coal-seam in South Staffordshire varies from 12 to 30 feet in thickness, and lies at varying depths from surface open-works to 2,100 feet at Hamstead colliery, where it is about 20 feet thick (Fig. 1, Plate XVII.). It is not properly a seam, but a number of seams piled one upon the other, often separated by layers of dirt, fire-clay or bat, varying in thickness from 1 inch to 30 inches, as follows :—

* "The Search of Coal over the Eastern Boundary-fault of the South Staffordshire Coal-field," by Mr. F. G. Meachem, *Trans. Inst. M.E.*, vol. viii., page 401.

† "Investigations on the Composition, Occurrence and Properties of Black-damp," by Messrs. John S. Haldane and W. N. Atkinson, *Ibid.*, vol. viii., page 549.

SECTION OF THICK COAL-SEAM.

	Ft. In.	Ft. In.
Roof—Rock	—	
Thick Coal-seam—		
COAL, Roofs	4 0	
Parting	0 3	
COAL, Top Slipper	4 0	
Parting	—	
COAL, Lambs, Tow (tough) and Brazils	5 4	
Parting	0 4	
COAL, Foot	1 6	
Parting	0 2	
COAL, Slips	2 10	
Hard stone	0 10	
COAL, Stone	3 10	
Parting	—	
COAL, Sawyer and Slipper	4 0	
Parting	0 2	
COAL, Benches	2 0	
		29 3
Floor—Fire-clay	—	

The various seams of which the Thick coal-seam is composed are not all alike in quality or hardness. For instance, the Brazils coal, if properly worked, will make 80 per cent. of large coal, while the Slips, Stone and Benches coals will only make slack, hence it is that only about 40 per cent. of large coal is made, leaving 60 per cent. of slack or fine coal. This fact also affects the working, for with a foundation to the pillars and ribs of soft coal it is impossible to keep the places quiet, as a continual movement or slipping is going on, and this in conjunction with the fact that where the Thick coal-seam lies under the Upper Red Coal-measures there is not a single rock of any strength or thickness between it and the surface. Hence, even at a depth of 2,100 feet, the workings lower canals, houses, etc.

Very many systems of working this seam have been tried, and most mining engineers think that a better system will be found; but at the present time, after nearly 300 years of practical experience and experiment, the pillar-and-stall method stands pre-eminent. This system has to be varied in the placing and size of ribs and pillars, even in one pit. A description, with plans, of the special procedure adopted at Hamstead colliery will be found in the first of the two papers mentioned above.

Heat Formed in the Workings.

It is commonly assumed, that as air passes through the workings of a coal-mine, heat is withdrawn from the neighbouring strata, and passes out in the return air, so that the general effect of opening out the mine is to cool the portion of the earth's crust through which the workings ramify. The writers' observations show that this theory is incorrect, and that, on the contrary, the general effect of opening out a mine is to warm both the coal and the strata adjacent to the workings.

On the surface, at Hamstead colliery, the mean annual temperature is, according to the generally accepted data, about 49° Fahr.* In the intake air-current at the pit-bottom, the temperature is far more constant than at the surface. During the prolonged frost of January and February, 1895, the average temperature at the pit-bottom was 50° Fahr., while on the surface it was 25½° Fahr. The lowest temperature observed at the pit-bottom was 43° on February 8th, 1895, with a surface-temperature of 4°. In hot weather, the air at the pit-bottom is cooler than on the surface. Thus on August 5th, 1892, to take an ordinary case, the surface-temperature (in the shade) was 67°, while at the same time at the pit-bottom it was 62°. On an average, the temperature at the pit-bottom is about 60°, or 11° higher than on the surface; and, in ordinary weather, the range of variation is very small. It is evident from these observations that during the 3½ minutes required with the ordinary ventilation for its passage down the shaft, the air approximately reaches the temperature of the shaft-walls. Their temperature at any given point in the shaft will depend chiefly on the average temperature of the air passing them, but partly also on the natural temperature of the strata. The air is compressed, and thus heated, as it descends the shaft; and as the heating-effect due to compression is about 5½° for every 1,000 feet of descent, the mean temperature of the air will naturally be about 10° higher at the pit-bottom than at the surface. Thus the higher mean temperature at the pit-bottom might be accounted for, without assuming that on an average the air extracts any appreciable quantity of heat from the strata round the shaft. As, however, a little moisture is taken up in the shaft, and this must tend to cool the walls, a certain amount of heat is undoubtedly communicated to the air from the strata.

From the pit-bottom, the temperature of the air rises steadily along the main intake airways, at the same time becoming less and less affected by changes in the temperature at the surface. Following the main north intake airway, the rise is at the rate of about 6° for every 3,000 feet, and at 6,000 feet from the shaft the temperature is 71°. In the workings, the temperature is commonly about 80° to 85°.

In the return airways, there is a slow, though steady, fall of temperature from the face towards the upcast shaft; but the fall is not nearly so marked as the rise in the intake airways from the shaft to the

* According to figures kindly supplied by the curator, Mr. Alfred Cresswell, the mean of the daily maxima and minima temperatures at Edgbaston Observatory from 1887 to 1897 was 47·5° Fahr. Allowing for the difference in level between the colliery and the observatory, this gives a figure almost the same as that given above.

face. Thus, the average temperature in the main north return airway at the shaft is 77°, as against 60° in the intake airway. As will be shown below, from the analyses of the air, the fall in temperature, along the return airway, is attributable to the passage of air across from the intake to the return airways. The writers have little doubt that, but for this leakage, the temperature would rise continuously along the course of the air-current from the top of the downcast to the bottom of the upcast shaft.

As was mentioned in a previous paper by one of the writers, the natural temperature of the undisturbed strata at the level of the pit-bottom (1,880 feet below the surface) is 66°. This was ascertained by inserting a maximum and minimum thermometer, protected by a metal case, into the end of 10 feet boreholes in freshly cut coal, at places distant from previous workings. The hole was then closed with clay, and left undisturbed for several days and sometimes for much longer periods. In repeated experiments, the minimum index showed that the temperature had fallen to 66°. These observations indicate a rise in the natural temperature of the undisturbed strata at Hamstead of 1° Fahr. for every 110 feet of descent from the surface The writers recently made further observations at a borehole in freshly-opened coal, in a part of the workings lying at a depth of 2,086 feet from the surface. The minimum index when examined at the end of two days, showed a fall from 76° to 68°. As 68° is 2° above 66°, which was the temperature at 1,880 feet, this observation indicated a rise of 2° for the extra 200 feet in depth, or a mean increase of 1° Fahr. for every 110 feet of descent from the surface, which is practically the same result as that given by previous observations. It is generally assumed that there is a mean rise of 1° Fahr. for about every 60 feet of descent.* The results obtained at different places vary greatly, however. Thus in the borehole of the Bootle well, near Liverpool, there was a rise of only 1° Fahr. in 130 feet, at Ashton Moss colliery 1° in 82 feet, at Rosebridge colliery 1° in 54 feet, while in other mines there was as much as 1° Fahr. in 40 feet. The divergence in the results is probably in part due to increase in temperature of the strata after their exposure to air; but the rate of rise at Hamstead is certainly less rapid than the true rate at most places.

When the thermometer was inserted in a borehole, not in virgin coal, but in coal which had been long exposed, the result was very different,

* "Report of the Committee appointed for the Purpose of Investigating the Rate of Increase of Underground Temperatures," *Report of the British Association for the Advancement of Science*, 1882, 1883 and later.

and the temperature found was much higher. The coal behind an exposed surface gradually rises in temperature, month by month, and year by year. Thus at two places in the side of a main road, where the temperature at the end of a 10 feet borehole was 66° in 1894, the writers recently (1898) found that it had risen to 83° and 90°. With every fresh panel of work, the temperature in the workings gradually rises from the beginning, until, as a general rule, the panel has, at some time or other, to be sealed and left to cool, on account of the danger of fire. As will be shown hereinafter, this gradual heating effect is very evident along the lines of the main roads, especially in the return airways, in the sides of which, after a time, spontaneous fires are very apt to occur.

It is very clear, from the facts already stated, that the whole, or nearly the whole, of the heat which is constantly being withdrawn from the workings and roads of the pit by the air-current is derived, not from the natural heat of the undisturbed strata, but from processes incidental to the working of the pit. Even the heat withdrawn in the first 3,000 feet of the intake airway, where the mean temperature of the road is still below the natural temperature of the strata, seems, from the chemical evidence given below, to be all derived from this latter source.

The total amount of heat liberated in the mine cannot be calculated merely from observations of the temperature and amount of the air-currents, for it is evident that in addition to the heat withdrawn from the mine by the air-currents, a large amount must pass outwards by conduction through the walls, roof and floor, to the cooler strata surrounding the mine. It will be useful, however, to calculate the amount of that portion of the heat liberated which escapes by the return air-current. In the main north intake airway, the mean temperature is about 60°, and the air is about 80 per cent. saturated with moisture, while in the corresponding main north return airway the mean temperature is about 77°, with the air about 85 per cent. saturated. The average current, shown by anemometer-readings, is about 50,000 cubic feet of air per minute. Taking the specific gravity of the air in the return airway as 0·00125, its specific heat as 0·24, and the weight of 1 cubic foot of water as 62 pounds, the amount of heat withdrawn per minute in virtue of the warming of the air would be, measured in terms of pounds of water raised 1° Fahr. (pound-degrees), ($50{,}000 \times 0{\cdot}00125 \times 0{\cdot}24 \times 62 \times [77^\circ - 60^\circ] =$) about 16,000 units. To this should be added the latent heat due to the evaporation of the excess

of moisture contained in the return air-current. Since the tension of aqueous vapour at 60° Fahr. is 13·1 millimetres of mercury, and at 77° is 23·5 millimetres; and since the specific gravity of aqueous vapour at standard pressure and temperature is 0·00079, and the latent heat of aqueous vapour at the mine temperature about 1,060 Fahrenheit units, the latent heat leaving the mine per minute by the return air-current will be $(50{,}000 \times [\{23{\cdot}5 \times 0{\cdot}85\} - \{13{\cdot}1 \times 0{\cdot}80\}] \div 760 \times 0{\cdot}00079 \times 1{,}060 \times 62 =)$ about 32,000 pound degrees.

Hence, the total heat carried away per minute by the air-current is $(16{,}000 + 32{,}000 =)$ 48,000 pound-degrees, and, roughly speaking, each cubic foot of air passed through the mine carries off with it one pound-degree of heat.

It has been shown already that little or none of this heat can have its source in the natural heat of the strata, so that it must be derived from some process, or processes, occurring in the pit itself.

Possible Sources of Heat in the Mine.

Of the possible sources of heat in a pit, the one which might, perhaps, present itself first is the presence of men and horses, and the burning of candles. A simple calculation serves to show, however, that this source of heat is insignificant. In the workings and roads on the north side of the shaft, there are employed on an average of the 24 hours 115 men and 30 horses. A man gives off per minute on an average of the 24 hours sufficient heat to raise about 8 pounds of water 1° Fahr. As, however, he is at work while in the pit, he will probably be giving off about twice as much on an average. A horse gives off about three times as much heat as a man; and a candle, which burns about 2 grains of tallow per minute, gives off about 4 pound-degrees per minute, or a quarter as much heat as a man at work. The sum total of units of heat is thus $([115 \times 16] + [115 \times 4] + [30 \times 48] =)$ 3,740. This would only account for about 7 per cent. of the heat leaving the mine by the return air-current, even on the extreme assumption that the whole of the heat due to men, candles, etc., was actually carried off by the air-current to the upcast shaft.

A second possible source of heat is the friction due to the constant settling down of the roof, and consequent grinding of coal and other material by the tremendous pressure of the superincumbent strata. The workings at Hamstead are 2,000 feet below the surface, hence assuming that the average specific gravity of the superincumbent strata is some-

where about 2, and that consequently 1 cubic foot of strata weighs 125 lbs, the average pressure on the coal will be (125 × 2,000 =) 250,000 lbs. per square foot, or about 0·8 ton per square inch. Now, as the average output of coal, etc., from the north side of the pit is about 650 tons per day, or about ½ ton, or 15 cubic feet per minute, it is clear that the average rate of settling down of the strata above cannot exceed 15 cubic feet per minute. In the process of settling down, to fill up the vacant space left by 15 cubic feet of coal, the heat liberated is equivalent to (15 × 250,000 =) 3,750,000 foot-pounds of work; and as 772 foot-pounds are the mechanical equivalent of 1 pound-degree, the actual heating effect will be (3,750,000 ÷ 772 =) 4,850 units. It is quite certain that nothing like the whole of this heat would be actually liberated in the mine; but even assuming that it were, and that the whole of this heat went off by the return air-current, only about 10 per cent. of the heat withdrawn by the air-current would be accounted for. The writers may thus dismiss the friction due to downward crush of the strata as a quite insignificant cause of general rise in temperature of the mine.

Another source of heat is the friction due to the resistance met with by the air-current in passing through the mine. The vacuum at the fan-drift is equal to about 2½ inches of water-gauge, or 13 pounds per square foot. The energy converted into heat in the roads and workings, is thus equivalent to about (13 × 50,000 =) 650,000 foot-pounds This, however, corresponds to only 842 pound-degrees, or only 1·7 per cent. of the heat withdrawn by the air-current.

The only other possible source of heat in the mine is the chemical action of the air on the exposed coal and other material. On this source, the writers have made a number of observations.

General Nature and Amount of the Oxidation-processes in the Mine.

To determine the nature and amount of the oxidation-processes in the mine, a number of chemical analyses of the air were made; and these were supplemented by various laboratory-experiments carried out at the Physiological Laboratory, Oxford. The methods employed, for collecting and analysing the samples of air, were those recently described in full by one of the writers.* In the first series of experiments described below, the gas-burette employed† gave results reliable to

* *Journal of Physiology*, 1898, vol. xxii., page 465. † *Loc. cit.*, page 426.

about 0·025 per cent. for oxygen and carbonic acid, and to 0·05 per cent. for fire-damp (determined by explosion). In all the subsequent experiments, the burette for delicate work was employed,* and the fire-damp determined with the help of a Coquillion platinum spiral,† the results being reliable to about 0·005 per cent. It is evident that as the air in a main airway of any well ventilated mine differs but little in composition from pure air, accurate methods of analysis are essential.

To give a general idea of the nature and amount of the impurities present in the air of the mine, the writers will first detail the results of a series of analyses of samples taken on February 17th, 1897, at various points (see Plan, Fig. 2, Plate XVII.) along the course of the main north intake and return airways, and some of their branches, the temperatures at the same points being also stated. The temperatures were taken with a thermometer tested at Kew. The barometer was almost steady at 30·2 inches during the day; and the current measured as passing from the main north return airway was 57,000 cubic feet per minute, at a pressure of 32·0 inches. In Table I. (in the column headed "deficiency of oxygen") only the deficiency due to absorption of oxygen by the coal is tabulated, the very slight additional deficiency due to dilution of the air with fire-damp being deducted from the result of the analysis. The figures are calculated by deducting the actual oxygen-percentage found from the oxygen-percentage given by the same gas-burette for pure air, and then deducting from the result the deficiency due to dilution with fire-damp. For the carbonic acid, the figures are calculated by deducting from the actual result the percentage of carbonic acid (0·030 per cent.) present in pure air. The tightness of the corks in the sample-bottles was ascertained by observing whether air bubbled out when the corks were loosened under mercury. As the bottles were closed at a pressure of 32 inches of mercury, air always bubbled out unless there had been leakage.

The analyses in Table I. bring out several points clearly. In the first place, it is evident that as the air passes through the pit it steadily loses oxygen, and gains in carbonic acid. On an average, however, the loss in oxygen is 3·13 times the gain in carbonic acid. In this respect, the return air-current at Hamstead seems to differ from that of most other collieries,‡ where the ratio of diminution in oxygen to increase of carbonic acid is usually about 1·6.

* *Loc. cit.*, page 475. † *Loc. cit.*, page 473.

‡ *Trans. Inst. M.E.*, Messrs. Haldane and Atkinson, vol. viii., page 549, and vol. xi., page 265.

TABLE I.—ANALYSES OF SAMPLES OF AIR.

No. and Position on Plan.	Name of Road.	Distance from Shafts.	Temperature.	Deficiency of Oxygen.	Carbonic Acid in Excess.	Fire-damp.
		Feet.	Degs. Fahr.	Per Cent.	Per Cent	Per Cent.
A	Main North Intake Airway	150	55	0·00	0·000	0·00
A	Main North Return Airway	150	74	0·37	0·100	0·06
B	North Intake Airway	5,850	71	0·16	0·090	0·05 ?
B	North Return Airway	5,850	78	0·36	0·100	0·06
C	Intake Airway ...	7,920	73	0·25	0·095	—
C	Return Airway ...	7,920	80	0·77	{ 0·250 0·280	0 06
D	Intake Airway ...	9,150	83	0·88	{ 0·310 0·330	0·11
D	Return Airway ...	9,150	83	1·70	{ 0·470 0·470	0·28
E	Main South Intake Airway	150	55	0·01	0·000	—
E	Main South Return Airway	150	- -	0·24	0·095	0·07

A second point is that a large proportion of the chemical change in the air occurs along the intake airways (which are situated in the solid coal).

Another striking point is that on the whole the rise in temperature of the air, whether in intake or return airways, increases with the diminution of the oxygen of the air. This fact is brought out clearly by arranging the results in the order of the temperatures observed as shown in Table II.

TABLE II.

Temperature. Degs. Fahr.	Deficiency of Oxygen. Per Cent.	Temperature. Degs. Fahr.	Deficiency of Oxygen. Per Cent.
55	0·00	78	0·36
71	0·16	80	0·77
73	0·25	83	0·88
74	0·37	83	1·70

The analyses also showed very clearly that the distribution of the air-supply in the pit was not even, in relation to the chemical impurities in the air. Thus while the air of the main north return airway was only 0·37 per cent. deficient in oxygen, the air of the intake airway at D was 0·83 per cent. deficient, and of the return airway 1·70 per cent. deficient.

Before proceeding to discuss these data further, the writers will record the results of further analyses.

A second series of analyses of return air-currents are recorded in Table III.

TABLE III.—ANALYSES OF SAMPLES OF AIR.

No. and Position on Plan.	Name of Road.	Distance from Shaft.	Date.	Deficiency of Oxygen.	Carbonic Acid in Excess.	Fire-damp.
		Feet.		Per Cent.	Per Cent.	Per Cent.
C	Return Airway ...	7,920	Jan., 1897	1·16	0·290	—
D	Return Airway ...	9,150	,, ,,	1·20	0·330	0·200
F	Return Airway ...	6,900	,, ,,	1·26	0·350	0·380
F	Lady Scott's back workings ...	6,900	June 6, 1898	1·32	0·357	0·387

In order to ascertain the changes produced in air, which had been left for a long time in contact with coal in the pit, a sample was taken of the gas issuing from behind an air-dam which had been put in to seal up some old workings off the main south return airway. There was no perceptible heat at this dam, and the gas issuing was quite cool. The gas in the first sample (March 9th, 1897) was collected over water. As the water must have absorbed a little of the carbonic acid, a second (June 10th, 1898) and a third (June 15th, 1898) sample were taken later by the ordinary method of displacement of air. The results are recorded in Table IV.

TABLE IV.—ANALYSES OF SAMPLES OF AIR.

Composition.	Sample 1 (over Water). Per Cent.	Sample 2. Per Cent.	Sample 3. Per Cent.
Oxygen ...	8·88	8·53	3·35
Carbonic acid ...	3·63	4·24 / 4·25	5·25
Nitrogen ...	87·46 (Nitrogen and Fire-damp)	82·89	8[illegible]·07
Fire-damp ...		4·34	7·33
Carbonic oxide ...	0·03	—	—
Oxygen diminished (by oxidation) ...	—	12·03	17·34
Carbonic acid increased (by oxidation) ...	—	4·40	5·60

The result shows that the ratio between the diminution of oxygen and excess of carbonic acid (2·94 to 1) was slightly lower than in the air of the return airways. The carbonic oxide in the first sample was determined directly with blood solution, so that there was no doubt that the small trace found was actually present.

Another sample was taken of the gas issuing through a pipe from behind a fire-stopping (No. 5 dam, east side). The stopping was warm, and the air in the road leading to it much vitiated. A pigeon, which the writers had taken with them to indicate any danger from carbonic oxide, died suddenly when placed in the line of the escaping gas. Its blood was found to be highly saturated with carbonic oxide. The analysis is shown in Table V.

TABLE V.

	Per Cent.
Oxygen	2·31
Carbonic acid	10·26
Fire-damp	1·64
Carbonic oxide	1·25
Nitrogen	84 54

In this case, there was very hot coal behind the stopping, and, as might be expected, the ratio between oxygen consumed and carbonic acid formed was not the same as in the other samples.

On January 4th and 5th, 1898, the writers made a further series of tests of the air in the roads on the north side of the pit. As the previous experiments had indicated that the ratio between the excess of carbonic acid and deficiency of oxygen was fairly constant along all the roads, the writers only determined the carbonic acid in this series, using, however, the method of analysis giving results correct to 0·005 per cent., so as to avoid errors due to the very small proportion of carbonic acid present in the air. The results are recorded in Table VI.

TABLE VI.

No. and Position on Plan.	Name of Road.	Distance from Shafts.	Temperature.	Carbonic Acid in Excess of Pure Air.	Fire-damp.
Jan. 4, 1898.		Feet.	Degs. Fahr.	Per Cent.	Per Cent.
A	Main North Intake Airway	150	57	0·002	—
A	Main North Return Airway	150	77	0·158	—
G	No. 6 East, in Bough's Bolt-hole	2,400	—	0·119	—
H	No. 5 East (intake), end of New Cross-road	2,700	69	0·094 ?	—
H	No. 5 East (return), end of New Cross-road	2,700	78	0·211	—
I	No. 5 East (intake), at Barker's Corner	5 100	71	0·057	—
I	No. 6 East (return), at Barker's Corner	5,100	79	0·218	—
J	No. 5 East (intake), near No. 1 Road	6,600	—	0·076	—
J	No. 5 East Return Airway	6,600	—	0·245	—
J	No. 19 Road, Scott's Return Airway	6,600	—	0·266	—
J	Return Airway from No. 3 Road off No. 5 East ..	6,600	—	0·306	—
Jan. 5, 1898.					
A	Main North Return Airway	150	77	0·210	0·112
G	No. 6 East (intake), in Bough's Bolt-hole ...	2,400	—	0·114	---
H	No. 5 East (intake), end of New Cross-road ...	2,700	69	0·032	-
H	End of New Cross-road (return)	2,700	78·5	0·287	---

Table VI. shows the same correspondence between temperature of roads and vitiation of air as in the previous experiments. The proportion of carbonic acid, etc., present in the air is, however, considerably greater than before, particularly on the second day. This the writers believe to be due to the fact that on the second day the barometer was falling, though not very rapidly. With a low barometer, nitrogen, carbonic acid and fire-damp must issue from old workings, and from the pores and cracks in the solid coal. This issue of gas is very evident at fire-stoppings, the roads leading up to which may become inaccessible from the amount of carbonic oxide present in the air, with a falling or low barometer. With regard to the issue of nitrogen and carbonic acid from the solid strata, the writers may call to mind the observations made recently by one of them, on the rapid issue of a similar mixture of gases from the strata round many ordinary wells with a falling, or low, barometer.*

The determinations of fire-damp are also of some interest. Fire-damp sufficient to show on an ordinary lamp is rarely met with in the course of ordinary work at Hamstead colliery, and open candles are in general use in the mine, as in all other collieries working the Thick coal-seam; yet the analyses show that traces of fire-damp are always present in the return airways. It is very doubtful whether the air of any coal-mine is perfectly free from fire-damp; and it would be of interest to know, whether by employing the same delicate methods of analysis as those applied in this investigation, fire-damp could not be detected in the return air of all coal-mines.

Experiments on the Action of Coal on Air.

In order to investigate the action of coal on air, we have made a number of laboratory experiments with samples of the Thick coal from Hamstead. In the first series of experiments, the coal was simply pounded up in a mortar, and placed in a thick-walled flask or bottle. The bottle (Fig. 3, Plate XVII.) was then closed tightly by means of a cork soaked in paraffin. Through this cork there passed a piece of glass tubing bent round, so as to form a manometer, the limbs of which were half filled with mercury. The flask was then left to itself, the temperature and barometric pressure having first been noted. When a sample of any coal is tested in this way, one or other of two effects will be observed. Either the gauge will indicate a gradual increase of

* *Trans. Inst. M.E.*, vol. xi., page 265.

pressure, or a gradual diminution. If the coal be freshly got, and from a fiery mine, an increase of pressure will be observed, and the mercury will after a time be blown out. An analysis of the gas in the flask will at once show that the pressure is due to evolution of fire-damp. A fiery coal which has stood for months, or even years, in lumps, but which is freshly pounded before being put in, may still show an increase of pressure. If, however, the coal, like that from the Hamstead colliery, is not fiery, and has been given time to drain off any small quantity of fire-damp present in it, the pressure in the flask will steadily diminish, and at last fall to nearly 21 per cent. of the atmospheric pressure under which it was closed. It will then be found that the residual gas is nearly pure nitrogen, the oxygen of the air having been absorbed by the coal. This, at least, is the result with the Hamstead coal, and with such other samples of non-fiery coal as the writers have hitherto tested. Of course, however, when fire-damp is given off, all sorts of intermediate results may be obtained, and even the Hamstead coal when fresh from the pit, and pounded up just before the experiment, will give an increase of pressure from evolution of fire-damp.

The following are the notes of a prolonged experiment :—Coal from Bough's bolt-hole, Hamstead colliery, sent up 3 months previously, and allowed to lie in lumps in the laboratory since then. The coal was pounded in a mortar, and left spread out in a thin layer for 2 hours before being put into the flask. The flask was immersed in water, so that its temperature could easily be ascertained. The observations of the pressure indicated by the manometer (Table VII.) are corrected for variations of temperature and barometric pressure. The bore of the manometer-tubing was almost capillary (about 1 millimetre), and the flask was a large one of about 2 pints capacity. The temperature averaged about 54° Fahr. during the first week.

TABLE VII.

Time since closing Flask.	Negative Pressure of Mercury. Inches.	Time since closing Flask.	Negative Pressure of Mercury. Inches.
1 hour	0·15	4 days	5·05
5 hours	0·65	5 ,, ...	5·45
12 ,, ...	1·25	6 ,, ...	5·75
24 ,, ...	2·00	7 ,, ...	6·00
36 ,, ...	2·80	9 ,, ...	6·10
48 ,, ...	3·40	11 ,, ...	6·10
56 ,, ...	3·85	24 ,, ...	6·00
72 ,, ...	4·30	6 months	5·85

A sample of gas was now withdrawn from the flask and analysed, with the result shown in Table VIII.

TABLE VIII.

Oxygen	0·066
Carbonic acid	1·284
Fire-damp	0·651
Carbonic oxide	0·042
Nitrogen	97·957

The barometer stood at 29·75 inches when the flask was closed, and 5·85 inches is 19·6 per cent. of 29·95 inches. From the analysis, a diminution in pressure of 19·3 per cent. would be expected on the theory that nitrogen is neither absorbed nor given off by the coal, so that the result accords almost exactly with this theory.

A sample of fresh pounded coal from the same large lump as was used in this experiment gave, in an experiment made two days after the coal had been got, a slight increase of pressure in the flask. A sample of the air in contact with the coal showed that the oxygen had diminished by 4·01 per cent., while the carbonic acid had increased by 0·38 per cent., and 3·85 per cent. of fire-damp was present. As (3·85 + 0·38 =) 4·23 is more than 4·01 per cent., the increase in pressure is fully accounted for by the fire-damp coming off. In another longer experiment, begun next day with the same sample of pounded coal, after it had been thoroughly ventilated with air, the pressure fell within 24 hours by 2·9 inches. As it appeared now to be beginning to rise again slowly, a sample was taken for analysis. The oxygen was diminished by 14·90 per cent., the carbonic acid had increased by 0·50 per cent., and there was 4·72 per cent. of fire-damp. If (4·72 + 0·50 =) 5·22 be deducted from 14·90, the remainder is 9·68 per cent. The barometric pressure when the flask was closed was 30·4 inches, and 2·9 inches is 9·54 per cent. of 30·4 inches, so that here again the result agrees as closely as could be expected with the theory that nothing is given off but fire-damp and a little carbonic acid, and nothing absorbed but oxygen.

In the course of these experiments, one very unexpected observation was made. The writers had taken it to be almost certain that no other gases would be found in the flask at the end of an experiment than nitrogen (including argon, etc.) and a little fire-damp (methane). In determining the methane by combustion with oxygen in presence of a heated platinum spiral, it was, however, found that the volume of carbonic acid formed amounted to more than half the volume of the contraction on combustion, while with pure fire-damp the contraction should be exactly half, in accordance with the equation $CH_4 + 2\ O_2 = CO_2 + 2\ H_2O$. This pointed to the presence, either of carbonic oxide, or of some other carbon compound containing a larger proportion of

carbon than fire-damp. On testing some of the gas with blood-solution the carbonic-oxide reaction was at once obtained, and it was further found that the determination of the carbonic oxide by combustion, on the theory that the combustible gas was a mixture of carbonic oxide and fire-damp, gave as exactly as could be expected the same result as when the carbonic oxide was determined with blood-solution. In one experiment, 0·18 per cent. of carbonic oxide and 0·39 per cent. of fire-damp were found ; and in another (a shorter one of three days' duration, at the end of which there was still 7·99 per cent. of oxygen in the gas from the flask) 0·11 per cent. of carbonic oxide and 0·30 per cent. of fire-damp. The coal used had stood for 2 months in the laboratory in lumps, and had never been heated in any way. These observations, to the practical significance of which the writers hope to return in a future paper, show that carbonic oxide in small amount may be formed from coal at ordinary temperatures and without any heating.

In order to obtain quantitative data as to the rate of oxidation of coal, and the effect on the rate of oxidation of variation of temperature, the writers used the following arrangement. The sample of coal was placed in a bottle tubulated above and below, and provided with tightly-fitting perforated corks. Through the lower cork, a current of pure air was led in through glass tubing. The bottom of the flask was covered with fragments of pumice-stone, and resting on the pumice was a thick layer of coal, powdered or not as was desired. The air entering the bottle could spread freely through the pumice, from which it passed upwards in an even stream through the coal. After leaving the bottle containing the coal, the air passed through a smaller bottle, so arranged that it could at any time be disconnected and removed for analysis of the contained air. The air then passed to a small meter, measuring ½ litre per revolution of the drum, and thence to the aspirator, which consisted of an ordinary filter-pump fixed on a tap supplied from a cistern. The air-current was kept quite steady during an experiment, and regulated as desired, by means of a tap placed between the meter and the filter-pump. The bottle containing the coal was immersed in a water-bath heated by a gas-flame when required, and when the bath was heated to any required point the temperature was kept steady for at least 1 hour before a sample of the air was taken for analysis.

At the end of No. 1 experiment, the bottle was closed and allowed to cool, and 16 hours later a sample contained 0·27 per cent. of carbonic acid, 4·98 per cent. of oxygen, 0·23 per cent. of carbonic oxide, and 0·12 per cent. of fire-damp.

TABLE IX.—EXPERIMENT 1, WITH 0·92 POUND OF FINELY POUNDED COAL, SENT FROM THE PIT 4 DAYS PREVIOUSLY, AND FRESHLY POUNDED UP.

Temperature of Bath.	Time since Coal was Pounded up.	Rate of Ventilation per Hour.	Deficiency of Oxygen.	Carbonic Acid Increased.	Fire-damp and Carbonic Oxide.	Oxygen Absorbed per Ton of Coal and per Hour.
Degs. Fahr.	Hours.	Cubic Feet.	Per Cent.	Per Cent.	Per Cent.	Cubic Feet.
59	2	0·091	1·10	0·07	0·290	2·45
59	5	0·131	0·72	0·02	—	2·30
59	8	0·080	1·00	0·05	—	1·95
60	20	0·114	0·46	0·04	—	1·26*
101	25	0·114	1·29	0·05	0·075	3·58
108	29	0·114	1·48	0·12	0·100	4·11
125	32	0·103	2·18	0·10	0·110	5·59

* Ventilation left on for 12 hours since last determination.

TABLE X.—EXPERIMENT 2, WITH 2·7 POUNDS OF POUNDED COAL (SAME SAMPLE AS USED IN LAST EXPERIMENT) SENT FROM THE PIT 3 MONTHS PREVIOUSLY, AND FRAGMENTS POUNDED UP A FEW HOURS BEFORE THE EXPERIMENT.

Temperature of Bath.	Rate of Ventilation per Hour.	Deficiency of Oxygen.	Carbonic Acid Increased.	Fire-damp.	Carbonic Oxide.	Oxygen Absorbed per Ton of Coal and per Hour.
Degs. Fahr.	Cubic Feet.	Per Cent.	Per Cent.	Per Cent.	Per Cent	Cubic Feet.
59	0·078	0·40	0·09	0·00	0·00	0·26
160	0·084	5·31	0·67	0·07	0·14	3·70

The experiments recorded in Tables IX. and X. show that the coal from Hamstead colliery, when exposed to air at ordinary temperatures, steadily absorbs oxygen, and that this absorption of oxygen is by far the most prominent change. In addition to the absorption of oxygen, three gases (namely, fire-damp, carbonic acid, and a very small amount of carbonic oxide) are given off. The fire-damp nearly all drains off soon after the coal has been taken from the pit, but small traces continue to come off for some time afterwards. The carbonic acid seems always to be given off, however long the coal may have stood, and its formation is thus dependent in some way or other on the action of air. Its amount is, however, not only very small, but also very variable as compared with the volume of oxygen absorbed. In some of the analyses, the carbonic acid is as little as 3 per cent., while in others it is as much as 25 per cent. of the oxygen absorbed.

The experiments also bring out the influence (1) of the proportion of oxygen present in the air, (2) of temperature, and (3) of previous exposure to air, on the rate of absorption of oxygen by the coal :—

(1) The influence of the proportion of oxygen present in the air is clearly seen in the experiments quoted in full on the reduction of pres-

sure which occurs in a closed flask containing coal. If the small amounts of fire-damp and carbonic acid given off by the coal be neglected, the diminution in pressure from day to day is evidently a measure of the rate of absorption of oxygen, or of the diminution of the partial pressure which it exerts on the coal. In Table XI., the mean partial pressure from day to day is given in the first column ; the second column gives the volume of oxygen (reduced to the pressure at the beginning of the experiment) calculated as actually absorbed ; and the third column gives the volume of oxygen which would be absorbed were it the case that the rate of absorption depended, other things being equal, on the partial pressure of the oxygen.

TABLE XI.

Period.	Mean Partial Pressure of Oxygen in Percentage of 1 Atmosphere's Pressure.	Oxygen Absorbed.	
		Observed.	Calculated.
	Per Cent.	Per Cent.	Per Cent.
First 24 hours	17·6	6·7	6·7
Second 24 hours	11·9	4·7	4·5
Third 24 hours	7·9	3·1	3·1
Fourth 24 hours	5·2	2·5	2·1
Fifth 24 hours	3·2	1·3	1·3
Sixth 24 hours	2·1	1·0	0·8

It will be at once seen from Table XI. that the rate of absorption of oxygen varies as the partial pressure of the oxygen in the air. Hence, neglecting variations in atmospheric pressure, the rate of absorption of oxygen by coal varies directly with the percentage of oxygen present in the air.

It will be seen from this statement that the slow consumption of oxygen by coal follows a different law from the consumption of oxygen by an animal, or even by a burning flame. The animal regulates its own rate of consumption, so that it is exactly the same whether 10 per cent. or 100 per cent. of oxygen be present in the air. In the burning flame, the consumption of oxygen varies with the percentage of oxygen present ; but with less than a certain percentage (17·3) the flame is extinguished by the cooling influence of the excess of nitrogen (or carbonic acid) present in the air. The slow oxidation of finely divided coal, on the other hand, seems to go on simply in direct proportion to the percentage of oxygen present in the air. This law is of considerable practical interest in connexion with its bearing on the effects of cutting off the air-supply to a goaf or other part of a mine.

(2) The influence of temperature on the rate of absorption of oxygen is shown by the two experiments with the water-bath arrangement. It is evident that the rate of absorption increases rapidly with rise of temperature. Thus in No. 2 experiment, a rise of 101° (from 59° to 160°) increased the rate of absorption about 14 times. This gives a mean rate of increase according to which the absorption at 66° would be about double that at 59°, since (66 — 59 =) 7° are about 7 per cent. of 101°. It is quite evident, however, from No. 1 experiment that, starting from about 60°, a rise, not of merely 7° but of about 30° is required to double the rate of absorption ; and a closer examination of the figures obtained in No. 1 experiment, show that as the temperature rises in arithmetical progression, the rate of oxygen-absorption increases in geometrical progression, the ratio of increase being about $\frac{1}{10}$th for every 4° Fahr., or about 1 for every 29°. This will be clearly seen by the following comparison (Table XII.) between the results observed, and those calculated according to the law just enunciated.

TABLE XII.

Temperature.	Oxygen Absorbed per Ton of Coal and per Hour.	
	Observed	Calculated.
Degs. Fahr.	Cubic Feet.	Cubic Feet.
59	1·26	1·26
101	3·58	3·59
108	4·11	4·35
124	5·59	5·97

In No. 2 experiment, in which the temperature was raised to 160°, the rate of absorption at the latter temperature is 14 times that at 59° : while according to the rule given above, an increase to only 11 times would be expected. Possibly, therefore, the ratio of increase in absorption of oxygen is increased when the temperature becomes very high, and additional constituents of the coal become involved in the oxidation-process.

(3) The influence of previous exposure to air is clearly seen in the first four observations in No. 1 experiment, which were all made at about the same temperature. It will be seen that during the first 20 hours after the coal was pounded up, the rate of absorption of oxygen gradually fell to about one-half. In No. 2 experiment, which was made with a sample of the same coal similarly pounded up, after it had stood in the laboratory for 3 months in lumps, the rate of absorption of

oxygen was only 10 per cent. of that obtained with the freshly won coal. Coal quite freshly exposed in the pit would doubtless give a considerably more rapid rate of absorption than that observed in No. 1 experiment. Although the rate of absorption of oxygen by coal diminishes markedly with the period of exposure, yet there seems to be no definite period at which the absorption ceases. A sample (from another pit) which had stood in lumps for about 2 years in the laboratory, was still found to absorb oxygen when pounded up.

Nature of the Oxidizing Action of Air on Coal.

The fact that, when coal is left in contact with air, the oxygen of the latter disappears, has been known for long : also that coal left exposed to air in bulk in a finely divided condition will take fire spontaneously in consequence of the heat produced by the oxidizing action of the air. The exact nature of the oxidation-process is still, however, obscure. It was formerly very generally believed that the oxygen was absorbed wholly in the oxidation of iron pyrites (FeS_2). As, however, some observers found that carbonic acid was given off at the same time as oxygen was absorbed, and that the tendency of coals to spontaneous ignition did not depend on the percentage of iron pyrites contained in them, the iron-pyrites theory has been more or less given up, and it is commonly supposed that the carbon and hydrogen of the coal are attacked by the oxygen of the air. The evidence in favour of this latter theory is very clearly summarized by Dr. Percy.*

That carbonic acid is given off in the mine at the same time as oxygen is absorbed is clearly shown by analyses of the air in all parts of the pit. At Hamstead colliery, as was shown above, the average ratio between the diminution of oxygen and increase of carbonic acid percentage is a little above 3 in the return airways. In most other pits, the increase in carbonic acid is relatively much larger, the average ratio being apparently about 1·6.† The fact that carbonic acid is evolved in a pit at the same time as oxygen is absorbed is, however, no evidence that the carbon of the coal, or of any other material, is being oxidized by the air. As was recently shown by one of the writers, the air of wells sunk in sandstone and other strata containing no coal or other known forms of oxidizable carbon may be altered by diminution in the oxygen and excess of carbonic acid in exactly the same way as the air of a coal-

* *Metallurgy, Fuel*, 1875, pages 289 to 300.

† Messrs. Haldane and Atkinson, *Trans. Inst. M.E.*, vol. viii., page 549, and vol. xi., page 265.

mine. This alteration occurs in the pores of the strata round the wells, into and out of which the air is driven through the walls of the well by changes of barometric pressure. The following analyses (Table XIII.) of samples of air from Foxdale lead-mine show that the same process occurs in the air of metalliferous mines, where there is likewise no carbon in an oxidizable form present in the strata. These samples the writers owe to the courtesy of Dr. Le Neve Foster, H.M. inspector of mines, and Captain Kitto, of Foxdale mine, who selected the places at which they were to be collected, and accompanied one of the writers to the points in question. The vitiation occurring in the air of metalliferous mines is often attributed to the presence of men and lights, and the burning of explosives. These are doubtless important causes of local vitiation in the air. In the two last samples, however, vitiation by the two latter causes was entirely excluded; and in the first sample (from the return airway) only a very small portion of the vitiation could have been due to men and lights, as the air-current passing was very considerable. In all probability, therefore, the vitiation of the main air-currents in metalliferous mines and of the air in wells is due to very much the same causes as the vitiation (by oxidation) of the air of coal-mines.

TABLE XIII.—FOXDALE MINE, ISLE OF MAN, JUNE 18TH, 1897.

No. 1 sample, taken in a return airway, at the 1,470 feet level, close to the Beckwith (upcast) shaft. A good air-current, and air perfectly fresh:—

	Per Cent.
Carbonic acid increased	(a) 0·318 (b) 0·324
Oxygen diminished	0·340
Combustible gas, fire-damp, etc.	0·000

No. 2 sample, taken in the 1,470 feet level, north lode, from depression in sump, where gas extinctive to candles was collecting on the floor. On breathing this gas, the effects of carbonic acid were distinctly felt (increased depth and frequency of respirations):—

	Per Cent.
Carbonic acid increased	8·360
Oxygen diminished	8·260

No. 3 sample, taken from the 1,650 feet level, being extinctive gas coming out of end of cross-cut, above a stream of water:—

	Per Cent.
Carbonic acid increased	3·310
Oxygen diminished	5·810
Combustible gas	0·000

There are, of course, cases in which vitiation of underground air with carbonic acid by natural causes is apparently not connected in any way with oxidation. The classical example of such vitiation is that of the Grotto del Cane, near Naples. In order to make quite certain

that the vitiation in this case was due simply to the evolution of carbonic acid, a sample of the gas (collected by displacement of air in April, 1898, by Miss E. S. Haldane from near the floor of the grotto) was analysed. The result is shown in Table XIV.

TABLE XIV.

Analysis.	Per Cent.	Otherwise Expressed.	Per Cent.	Per Cent.
Carbonic acid	50·18	Carbonic acid		50·17
Oxygen	9·97	Air :—		
Nitrogen...	39·85	Oxygen	9·97	
Combustible gas	0·00	Nitrogen	37·70	
		Carbonic acid... ...	0·01	
			——	47·68
		Nitrogen...		2·15

It will be seen from Table XIV. that, although the sample has nearly the composition of a mixture of air and carbonic acid, there is a distinct excess of nitrogen, amounting to 2·15 per cent. This excess can, however, be explained easily if it be remembered that in the still air of the cave the mixture of carbonic acid and air doubtless occurs, not by mechanical mixture, but by diffusion. Nitrogen is lighter than air, and will therefore diffuse downwards into carbonic acid more rapidly than oxygen. Allowing for this fact and for the presence in air of 0·9 per cent. of argon (which in all the above analyses is included with nitrogen), the calculated composition of a mixture by diffusion of air and carbonic acid containing 50·18 per cent. of carbonic acid would be :—

	Per Cent.
Carbonic acid	50·18
Oxygen	9·92
Nitrogen	39·89

The composition actually found agrees with these figures as closely as possible, so that apparently the gas issuing from the floor in the Grotto del Cane is pure carbonic acid, without sensible admixture of any other gas.

Pure carbonic acid, such as that given off at the Grotto del Cane and in other volcanic districts, may very probably have its source in the decomposition of carbonates by silica at high temperatures. This source is, however, scarcely possible in the case of ordinary mines, where the temperature is near that of the surface, and where, moreover, the appearance of carbonic acid seems always to be closely associated with the disappearance of oxygen. The facts are, nevertheless, capable of satisfactory explanation by means of another hypothesis, namely, that the carbonic acid is simply liberated at ordinary temperatures from carbonates, and that this liberation occurs side by side with the oxidation-phenomena which led to the carbonic acid being set free.

In the workings of both metalliferous mines and coal-mines, as well as in other parts of the earth's crust, iron pyrites is, as a rule, present in greater or less abundance. In its oxidation it not only absorbs oxygen, but also forms sulphuric acid: which, whether free or in combination with iron, is capable of decomposing carbonates with evolution of carbonic acid. Carbonates are present as carbonate of lime (calcite) in coal, and carbonate of iron in one form or another is also commonly associated with iron pyrites. Thus, in the Foxdale mine, iron pyrites and spathic iron-ore (as well as calcite) were abundantly present in association with the galena for the sake of which the mine was worked. The decomposition of iron pyrites must thus tend always to be associated with liberation of carbonic acid as well as absorption of oxygen.

It is wellknown that ferrous or ferric sulphates are commonly found in the form of a crystalline incrustation on a face of coal which has been left for some time undisturbed in a pit: also that the water which collects in a pit is often acid, and corrosive to iron pipes, or may even destroy the soles of boots. In the tunnels of the Metropolitan railway, where the ground under foot is saturated with sulphuric acid formed by the combustion of coal, there is the same effect on the soles of boots. Mr. W. N. Atkinson, H.M. inspector of mines, has informed one of the writers, that he has even known a case in which combustible gas—evidently hydrogen formed by the action of the acid water on iron, had occurred in an iron pipe underground. On testing in the laboratory the veins of pyrites running through a lump of Hamstead coal, a slight acid reaction could easily be detected with litmus paper.

The chemical reactions occurring, when iron pyrites becomes completely oxidized in presence of a carbonate, are represented by the following equations:—

$$4\ FeS_2 + 15\ O_2 + 8\ H_2O = 2\ Fe_2O_3 + 8\ H_2SO_4;\ \text{and}$$
$$8\ H_2SO_4 + 8\ CaCO_3 = 8\ CO_2 + 8\ CaSO_4 + 8\ H_2O.$$

It will thus be seen that for every 15 volumes of oxygen which disappear in this reaction, 8 volumes of carbonic acid are liberated. It will be found on calculation that in air passing over such material, the ratio between diminution in oxygen and increase in carbonic-acid percentage will be 1·74. This corresponds closely with the average ratio observed in the air from old workings, etc., by Messrs. Haldane and Atkinson, and in the return air from most pits. At Hamstead colliery, and in the return air-current from workings in the Bulhurst coal-seam in North Staffordshire, the relative proportion of carbonic acid

increase is considerably less, possibly because not sufficient carbonate is present to satisfy all the sulphuric acid. In the case of the choke-damp of wells, the composition of the gas seems, as might be expected, to be more variable than in mines, the ratio observed varying from 0·8 to 5. In all cases where ferrous carbonate is present, the possibility of its oxidation to ferric oxide with liberation of carbonic acid, must be taken into account. In this process there is a large excess of carbonic acid formed over oxygen absorbed, the reaction being :—

$$4\ FeCO_3 + O_2 = 2\ Fe_2O_3 + 4\ CO_2.$$

As four volumes of carbonic acid are produced for every volume of oxygen absorbed, the ratio between diminution of oxygen and excess of carbonic acid in air passing over decomposing carbonate of iron will be 0·4. In other words, the choke-damp, or black-damp formed, will contain 51·3 per cent. of carbonic acid and 48·7 per cent. of nitrogen. Whether choke-damp approaching this composition is ever met with in ironstone-pits has not yet been ascertained. The only sample of choke-damp from an ironstone-pit, analysed by Messrs. Haldane and Atkinson, contained 14·7 per cent. of carbonic acid and 85·3 per cent. of nitrogen, and was, therefore, very probably formed chiefly through the oxidation of the iron pyrites, which is so commonly associated with carbonate of iron.

While there is as yet no direct evidence that the absorption of oxygen and evolution of carbonic acid in mines is due chiefly, if not entirely, to the oxidation of iron pyrites, yet it appears to the writers that no facts of which they are aware contradict this theory, and that in the present state of knowledge it is the simplest explanation of the phenomena, and ought not to be rejected until its inadequacy has been proved. The reasons in support of the iron-pyrites theory may be summarized as follows :—

1. There is no doubt of the facts (1) that iron pyrites undergoes slow oxidation in coal exposed to air; (2) that sulphuric acid is thus formed; (3) that this sulphuric acid must tend to evolve carbonic acid from the carbonates present in the neighbourhood of the pyrites; and (4) that the proportion of carbonic acid thus tending to be liberated is about sufficient to account for what is actually found to be liberated. The pyrites theory thus rests directly upon ascertained facts.

2. This theory explains the fact that the alterations (as regards oxygen and carbonic acid) in the air of coal-mines are so similar to those found in the air of metalliferous mines, wells, etc.

3. It also explains the fact that the evolution of carbonic acid from coal does not always run parallel to absorption of oxygen, although usually associated with it, and that in laboratory-experiments there may be great absorption of oxygen with hardly any evolution of carbonic acid.

4. It explains the fact that coal exposed to air increases both in dry weight and in percentage of oxygen to a certain limited extent, and that beyond this limit no further change occurs, or any change becomes so slow as to be inappreciable.* The fact that coal increases in dry weight on exposure to air seems to be quite inexplicable, on the theory that in the process of slow oxidation the oxygen converts the carbon and hydrogen into carbonic acid and water. The oxygen may, however, enter into combination with some organic substance in the coal.

Against the pyrites theory there is the fact that the tendency of coal to spontaneous heating does not vary with the percentage of pyrites The tendency to heating must, however, depend in any case on other conditions besides the percentage of pyrites. One of these conditions is the ease with which the coal is reduced to slack or powder, and another is probably the special form in which the pyrites is present. It is wellknown that different samples of pyrites differ very greatly in the ease with which they undergo oxidation in air.

Heat Formed in the Mine.

The writers may now proceed to calculate as nearly as possible the heat formed in the mine by oxidation, taking as a basis for calculation the iron-pyrites theory.

The average excess of carbonic acid found in the main north return air-current was 0·16, corresponding to (0·16 × 3·13 =) 0·50 per cent. of deficiency in oxygen. On calculation, it will be found that this corresponds to a loss of 0·59 per cent. of oxygen, the actual loss being greater than 0·50 per cent, since allowance has to be made for the fact that not only the percentage of oxygen, but also the total volume of air has diminished, so that 100 volumes of dry return air represent 100·43 volumes of dry intake air at the same pressure and temperature. As the air-current to the north side of the pit was 50,000 cubic feet per minute the consumption of oxygen was (50,000 × 0·0059 =) 295 cubic feet per minute.

The actual heat of combustion of iron pyrites does not seem to have been experimentally determined as yet, but it can be calculated

* See the experiments quoted in Dr. Percy's *Metallurgy, Fuel*, page 293.

approximately from the heats of combustion of iron and sulphur. The heat of formation of ferrous sulphide is exceedingly small ($Fe + S = FeS = 24,500$),* and it may safely be assumed that the same is true for iron pyrites. The equations for the heats of combustion of iron and sulphur are as follows :—

$$2\ Fe + 3\ O = Fe_2O_3 = 197,700\ ;\ \text{and}$$
$$S + 3\ O = SO_3\ (\text{solution}) = 141,000.$$

Combining these equations so as to get the heats of combustion of iron and sulphur in the proportions in which they exist in iron pyrites :—

$$2\ Fe + 4\ S + 15\ O = Fe_2O_3 + 4\ SO_3 = 197,700 + (4 \times 141,000) = 761,700.$$

A small addition would be necessary to represent the further heat liberated in the decomposition of carbonates by sulphuric acid; but this may be left out of account, as the heat of formation of iron pyrites, which would probably tell about equally in the opposite direction, has not been allowed for.

From the above equation, it follows that, as the atomic weight of oxygen is 16, for every ($15 \times 16 =$) 240 pounds of oxygen consumed in oxidizing iron pyrites, sufficient heat is liberated to raise 761,700 pounds of water 1° Cent. or 1·8° Fahr.; hence, for every pound of oxygen consumed about 5,700 pound-degrees of heat are formed.

As 295 cubic feet of oxygen are consumed per minute on the north side of the mine, and as 1 cubic foot of oxygen at the pit-bottom weighs about 0·09 pound, the total heat-production per minute by oxidation on the north side will be ($295 \times 0{\cdot}09 \times 5,700 =$) about 150,000 pound-degrees. In other words, the heat produced by oxidation in 1 minute in the northern half of the workings would suffice to raise 1 ton of water 67° Fahr. in temperature, or to raise the whole of the air passing from 60° to boiling-point (212°).

Now, according to the calculation previously made, the air-current carries away from the north side about 48,000 pound-degrees per minute. This is, however, only about one-third of the heat calculated as being formed. Thus the heat formed by oxidation in the mine not only accounts for the loss of heat by the air-current, but leaves a surplus of 100,000 pound-degrees per minute. This surplus must chiefly go

* The data here quoted are from Prof. Berthelot's *Thermo-chimie*, vol. ii. The units of heat are of course centigrade units, and the figures given indicate the number of pounds of water raised 1° Cent. for each pound of either of the elements entering into the reaction, multiplied by the atomic weight of the element, and by the number of atoms of it required to form a molecule of the resulting substance. Thus in the above reaction 1×56 lbs. of iron give 24,500 pound-degrees centigrade.

off into the surrounding strata by conduction, but will partly also accumulate, and so account for the gradual heating up of the coal. As compared with the heat formed by oxidation of the coal, that formed by men, candles, etc., is absolutely insignificant.

In the light of the results now reached, it is possible to explain an apparent anomaly in the distribution of temperature in the mine. From Table II.,* which gives the results of a combined series of temperature-observations and air-analyses, it will be seen that although the temperature rises at first with increasing vitiation of the air, yet when the rise of temperature or increase of vitiation in the air reaches a certain point the rule no longer holds, and further vitiation is not accompanied by any further temperature-increase. Thus, when the oxygen-percentage is diminished by more than 0·8 per cent. there appears to be no further rise in temperature, so that with 1·7 per cent. of diminution the temperature is just the same as with 0·88 per cent. The explanation seems evident enough. As the temperature of the air-current rises, the quantity of heat which it carries off from the coal becomes less and less. At the same time, the proportion of heat escaping by conduction into the surrounding strata becomes greater and greater, until at last a point is reached at which practically the whole of the heat escapes by the latter means, so that no further heating of the air-current occurs. In all probability, therefore, almost the whole of the heat withdrawn from the mine by the air-current is produced by oxidation along the course of the main air-roads, while nearly all of that produced at the working-face escapes by conduction through the strata. It would be of interest to compare the distribution of temperature and vitiation of air in the Hamstead colliery, where the main roads are driven in the centre of the Thick coal-seam, and the workings are on the pillar-and-stall system, with the distribution in a colliery on the longwall system (working outwards), and with roads surrounded only by stone or other non-oxidizable material.

As regards the chemical data on which the estimation of heat production in the mine is based, the writers would point out that it makes very little difference to the result whether the disappearance of oxygen be supposed to depend upon the oxidation of iron pyrites or upon that of carbon and hydrogen in the coal. In the latter case, the heat formed would be only slightly higher. A direct calorimetric determination of the heat produced by the slow oxidation of coal presents considerable experimental difficulties, but the writers hope at some time to be able

* *Trans. Inst. M.E.*, vol. xvi., page 465.

to make the attempt, as it seems a matter of great importance to clear up the doubts which still remain as to the heat liberated in the oxidation-processes occurring in mines.

It may be of interest to calculate the expenditure of energy which would be necessary in order to neutralize completely the heating-effects of oxidation in the north side of the mine at Hamstead. The heat formed is about 150,000 pound-degrees per minute. Converted into work, this represents (150,000 × 772 =) 115,800,000 foot-pounds of work, or (115,800,000 ÷ 33,000 =) 3,509 horsepower. Thus, supposing that this part of the mine had to be cooled by the liberation of compressed air within the workings, and that the compressed and cooled air could be conveyed into the mine without loss of energy, an engine of at least 3,500 horsepower would be required. To cool the working-places and roads by a few degrees would of course require a very much smaller expenditure of energy.

It might perhaps be supposed that the amount of heat liberated in the workings at Hamstead colliery is exceptional, and that in other coal-mines the admission of air has on the whole a cooling rather than a warming effect. This hypothesis appears to us to be quite untenable in face of the analyses which exist of return air. In other mines the composition of the return air is altered by oxidation of coal, etc., sometimes more and sometimes less than at Hamstead colliery. In very fiery mines, where the presence of fire-damp is the factor which determines the amount of the air-current, the change due to oxidation will naturally be less prominent; but still the air is vitiated by oxidation to an extent which proves that heat-production, on an enormous scale, is going on in the pit. Thus at Tylorstown colliery, in South Wales, with a current of 260,000 cubic feet of air per minute, the air was found to contain 20·27 per cent. of oxygen, 0·205 per cent. of carbonic acid, and 1·87 per cent. of fire-damp. The amount of oxygen which had disappeared by oxidation was therefore 0·29 per cent. of that present in the intake air. Calculating out the heat-production in the same way as for the north side of Hamstead colliery, the result is 3,400,000 pound-degrees of heat liberated per minute. This is a little more than 2½ times greater than the heat-production of the north half of Hamstead colliery (which receives almost exactly half of the total air-current), so that the total heat-production of Tylorstown colliery would seem to be greater than that of Hamstead colliery. The result is all the more remarkable since spontaneous underground fires are almost unknown in the South Wales coal-field. For metalliferous mines, the writers have no data as to both

composition and amount of the return air; but, to judge from the one analysis given above of the return air from the 1,470 feet level at the Foxdale lead-mine, the heat-production due to admission of air is very large, and far exceeds the heat withdrawn from the mine by the air-current. It would seem, therefore, that not only in all coal-mines, but probably also in metalliferous mines, the admission of air produces far more heat than it withdraws.

Although the general effect of ventilation is to warm a mine, yet it by no means follows that the ventilation does not, as a general rule, cool the intake roads. The circumstances in the Thick coal-seam are certainly more or less exceptional in this respect; since all the main-roads are driven in the centre of the seam, and are thus surrounded by material which is not only rapidly producing heat, but which is itself a very bad conductor of heat. For the same reason it seems probable that in mines with equal ventilation, and not working the Thick coal-seam, a larger proportion of the heat liberated will escape through the strata, as compared with what escapes by the ventilation-current. The greater the ventilation, however, the larger will be the proportion of heat carried off by the air-current, and therefore the cooler the mine. It would probably be found that at Tylorstown colliery, with its large air-current, more heat escapes by the air-current than by conduction into the strata.

This production of heat by oxidation is by no means an unmixed evil to miners; for it would seem to aid natural ventilation in a very essential manner. Natural ventilation depends on the fact, not merely that the temperature of a mine is higher than that of the outside air, but that the increase of temperature from above downwards in a shaft, is more rapid than the increase due to the compression of the air as it descends. The temperature of the strata at Hamstead colliery, for instance, being 66°, if there were no heating of the mine by oxidation, then there would be no tendency to natural ventilation unless the temperature at the surface were below 56°. At anything down to 56°, the air at the bottom of the shafts would still be in equilibrium with that above, just as air at 56° at the top of the shaft would be in equilibrium with air at 46° lying 2,000 feet above it. When, however, the increase in temperature due to oxidation is added to the increase due simply to the depth of the strata, there will be, at all ordinary surface-temperatures, a good natural ventilation-current, and this will very materially aid the action of the fan in a mine where a fan is employed.

Spontaneous Fires in the Thick Coal-seam, and Methods of Dealing with them.

The writers may now proceed to the consideration of spontaneous fires, and of the methods found by practical experience to be best in dealing with them.

The fires which are most frequent, and in fact the only fires which occur until the seam comes to be worked beyond a depth of 1,000 to 2,000 feet, are in the stalls, where the hewing has been done, and where fine slack coal mixed with dirt has been left on the floor. The manner in which these fires occur is readily intelligible in view of the experiments and calculations given above. It was found by experiment (Table IX.) that 1 ton of dust from coal which had been got 4 days previously absorbed about 2·4 cubic feet or 0·18 pound of oxygen per hour at a temperature of 59°. At the pit-temperature of about 80° to 85°, this absorption would be nearly twice as rapid, *i.e.*, about 0·3 pound per hour. Now, let us calculate what would happen to such a mass of material, assuming for the moment that it is abundantly supplied with air, and that no heat is lost. The absorption of 1 pound of oxygen corresponds, on the theory given above, to the liberation of 5,700 pound-degrees of heat; hence, an absorption of 0·3 pound corresponds to a liberation of 1,700 pound-degrees. Now, as there are 2,240 pounds in 1 ton, and as the specific heat of coal is only about a fourth of that of water, the temperature of the coal would be raised 4° at the end of 1 hour. As the temperature rose, the rate of oxidation would, according to the rule given, increase, at first slowly, but after a few hours with enormous rapidity, so that within less than 18 hours the coal would be in flames.

In an ordinary heap of slack, the subdivision of the coal is not so fine as in the case of the laboratory-experiments. The air-supply is, moreover, restricted; and much heat will escape by radiation, conduction, and evaporation of moisture. At first the air-supply will probably be adequate, but as the increments in consumption of oxygen increase with every degree of rise of temperature, whereas the corresponding increments in air-supply due to heating of the coal diminish with every degree of rise, a point must soon be reached where the air-supply becomes indequate, so that the mass can only smoulder, or burn at the surface.

The slack coal produced in working is not the only cause of fires in the stalls; it is often cleaned up, but as the workings proceed pillars with soft foundations are left behind, frequently under broken roof,

and this coal provides material for a gob-fire. Fires of this class are, however, easily dealt with by cutting off the air-supply, and Fig. 4, (Plate XVII.), shows how each panel is arranged with a view to its air-supply being at any time quickly and without trouble cut off by closing up the air-dams.

The dams are constructed of a barrier of fine dirt held up at the the back by a building of rocks or any available material (locally known as vye or dirt dams); in front the loose coals are all carefully cut away, and the vacant space is filled with fine sand for a distance of about 9 feet. Owing to the nature of the roof, these dams are often 20 feet high, and consequently have to be built proportionately stronger at the base. In a short time, the earth-movement tightens the dam to the roof, and then, if necessary, a brick wall filled in with fine sand, is built up in front.

In putting in dams, it has been always found desirable to erect the first dam in the return airway, and for the men to work with safety-lamps, for it must be remembered that coal or wood which is much heated always gives off gas, which is both explosive and poisonous. A deputy should always be left in charge of the workmen who understands gases and the methods of dealing with men overcome by carbonic oxide.

The writers now come to a class of fires that are unknown in shallow mines, viz., fires in the sides of the main-roads. When the roads are being driven out they are usually driven from 9 to 12 feet in width, but this width in deep mines disturbs the equilibrium of the strata, and what are locally known as "bumps" may occur. A bump is a sudden dislocation of the strata, accompanied by a loud and most alarming sound.* The side and bottom of the road may be broken, but the most serious results, so far as spontaneous fires are concerned, are the breaks produced on the sides of the road. These breaks generally occur from 6 to 15 feet from the side of the road, and by continual earth-movement become filled with fine coal-dust, which ignites, and forms large pockets of fire connected with the outer air by means of the fissures in the coal. Figs. 5, 6 and 7 (Plate XVII.), show the positions of various breaks, and of the headings made for the purpose of removing the burning coal from them.

Breaks may be divided into three classes, namely: (1) breaks in the coal itself, where the grain of the coal is actually broken across; (2) breaks along old lines of faults or face-things, or slickensides, where

* *Trans. Inst. M.E.*, vol. v., page 381; and vol. xii., pages 612.

the dislocation has not exceeded a few inches; and (3) breaks along old lines of faults or dislocations, where the intervening space has become filled up by infiltrations of calcite or iron pyrites. The latter class of breaks are the most troublesome.

A little consideration will show that the physical and chemical conditions along the line of a break are very favourable to the occurrence of fire: (1) the break is more or less filled with a mass of coal very finely divided, and thus in the condition most fitted to give rapid oxidation; (2) this powdered coal is surrounded on all sides by non-conducting material, so that the heat formed does not readily escape; (3) the breaks are so situated that there is apt to be a small, but more or less constant, air-current through them. This air-current depends on several conditions. Where, as in most parts of the mine, the coal along the sides of the roads is warmer than the air of the road, air will enter the breaks by fissures communicating with the road near the floor, and pass upwards and back into the road again by fissures near the roof. A second cause of air-supply to breaks situated in the solid coal between the intake and return airways is the excess of pressure in the intake airways. In consequence of this, there must be a constant oozing of air through the pores and fissures in the coal towards the return airway. A break or fissure, even when running parallel with a road, will act as a main channel for this flow of air, provided such break or fissure is in direct communication at some point with the road itself. At points where there is an overcast, or bolt-hole, the breaks will of course be apt to communicate more or less directly, on one side with the intake, and on the other with the return airway. If the air leaking through them is not sufficient to carry off the heat formed, the conditions for heating of the breaks will be fulfilled; a break communicating with a return airway at one end is specially dangerous, and if heating has occurred an extension of the break may suddenly increase the air-current, so that the fire is blown up and rapidly becomes extremely dangerous. A further cause of air-currents through breaks and fissures must also be mentioned. It is probable that with every rise of barometric pressure very large volumes of air are driven into and out of the pores existing in the solid coal extending on each side of a road. This air will return in the form of black-damp as the barometer falls again, just as occurs in the case of wells sunk in the strata near the surface. The breaks will of course tend to act as main channels for the passage of air inwards. To what extent changes of barometric pressure cause passage of air in and out of the solid coal we have not as yet determined by experiment.

If it be decided to dig out the fire, which is by far the best method and the only safe one in many instances, a careful examination should be made to find the entrance and exit of air and smoke. A very narrow heading should then be started on the intake side in order to supply fresh air as far as possible to the men engaged. A constant watch should be made upon the exit, if any, to see that the flames are not driven out on to the timber, as more air is let in by the heading. As soon as the fire is reached, if it be possible to dig it out without the aid of water it is wise to do so, for the heated water frequently starts a fire elsewhere in the Bench coal, and water-gas may be formed, which is very poisonous and when mixed with air has much wider limits of explosibility than fire-damp.

It often happens that as soon as the thin end of the break is reached the flames are forced back against the men, and water must be used to cope with this. If the fire be too bad, or seems to be getting beyond control, the heading must be tightly closed with sand and time allowed for partial extinction of the fire, or a new heading must be commenced.

It is always advisable either to follow the break until unheated coal is reached, or to put in other headings to the right and left so as to reach the breaks elsewhere. Care must be used to extinguish the burning material which is loaded up into the tubs, by pouring water on to it or putting sand on the top, in order that it may not flame up when in the intake road and set fire to timber.

Before commencing a heading, care should always be exercised in watching for and propping up loose "rates" or walls of coal on the sides, as it frequently happens that these rates are so insecure that if not so dealt with they might enhance the danger from fire; and if the Bench coal be carelessly taken out, or be not properly stretchered with timber, a bump may bring down the whole mass and set fire to the timber.

A very good fire-engine can be made by means of a circular tank mounted on wheels, fitted with pumps on the front, and a suction-pipe of sufficient length to reach to three or more tanks placed behind the fire-engine.

Prevention of Underground Fires.

Both practical experience at Hamstead colliery, and the results of the more special investigations communicated in the present paper, point towards certain measures for the prevention of spontaneous fires in the deep workings of the Thick coal-seam. A full discussion of the subject

would, however, involve somewhat wide questions, on which the writers can barely touch at present, as to the best methods of laying out the workings and getting the coal.

For practical purposes, three causes may be distinguished which in combination favour the occurrence of spontaneous fires in deep workings of the Thick coal-seam. These causes are :—(1) The fact that the Thick coal, whether at great depths or not, is specially liable to spontaneous ignition when broken up and left in sufficiently large masses in contact with air ; (2) the fact that at great depths the pressure of the superincumbent strata largely increases the liability of the coal to be ground up and exposed in a finely divided condition to air in breaks along the wall-sides of roads, and other similar situations ; (3) the fact that in a deep mine of large extent the temperature is high, and that a high temperature (as shown above) very greatly increases the rate at which the finely divided coal heats. Measures for the prevention of spontaneous fires may be considered under these three headings.

(1) The necessity of keeping the workings of a Thick coal-mine as far as possible free from slack or accumulations of any kind of finely divided coal, is generally recognized, and the writers need say nothing further on the subject.

(2) To diminish the great dangers arising from the grinding up of coal in breaks in the wall-sides of roads (and particularly main roads) various measures are desirable. (*a*) In the first place, it is of course greatly preferable, so far as danger from fire is concerned, that main roads should be driven, not in the substance of the Thick coal-seam, but in the strata either above or below it. The main roads of the pit are thus rendered much more secure, both the danger to life, and the very great pecuniary loss which may result from a fire on a main road, being avoided. If the roads are driven in the coal, the intake and return airways should be 200 feet or more apart, as otherwise the coal between them is specially liable to breaks and spontaneous fires. Bolt-holes, or connexions of any kind between intake and return airways should be placed as far apart as practically possible. Frequent bolt-holes, into which breaks are of course very apt to occur, are the greatest source of trouble. In driving bolt-holes, positions free from faults or breaks filled with calcite should be carefully selected.

(3) The high temperatures along the roads and in the workings may be reduced by several means. (*a*) The desirability from this point of view of having the main roads in strata not subject to oxidation is very obvious from the facts detailed above. With main roads in the stone,

there would certainly be very little rise in the temperature of the air between the pit-bottom and the working-face, whereas with roads in the coal, the air before it enters the workings has, in consequence of oxidation, risen so greatly in temperature that it carries off little or no heat from the workings, the consequence being that each panel of work tends to become hotter and hotter until finally it has to be closed on account of danger of fire. With workings a long way from the pit-bottom, the disadvantages of main roads in the coal are specially great. (*b*) Adequate ventilation is an essential condition in keeping down the temperature. If only the ventilation could be made large enough in relation to the oxidation proceeding in the mine, the temperature of the roads and working-places could certainly be kept at, or below, that of the strata, and the tendency to fires would thus be greatly diminished. In practice this is not attained, and in a mine subject to spontaneous combustion the cooling action of the available air must simply be used to the best possible advantage. When main roads are driven in coal, it is essential to keep them, and the bolt-holes, etc., connecting them, as cool as possible. All bolt-holes, etc., between intake and return airways must therefore be adequately ventilated, and sufficient air allowed to leak from the intake to the return airways so as to keep the latter fairly cool. In connexion with the cooling effects of ventilation, it must not be forgotten that air will absorb far more heat by taking up moisture than by simply rising in temperature. Thus, air saturated with moisture, and at 60°, will, in rising to, and becoming saturated at, 77°, absorb three times as much heat by taking up moisture as by mere rise in temperature. A marked local fall in temperature may thus often be obtained by the use of water-sprays, though the total cooling effect of the air on the mine is perhaps not increased.

As regards precautions for the early detection and localization of fires in deep thick coal workings, the writers recommend: (*a*) That constant examinations be made of all parts of the mine at intervals of not more than 2 hours; (*b*) that in places which are known to be dangerous, and where sides of work may have to be dammed off, dams should be erected with tubways through them, which can be readily closed in emergency; and (*c*) that slide planks prepared so as to fit in grooves, and sand, be placed ready at the main points in the mine, so that air-dams can be made with the least possible delay.

Conclusion.

The following are some of the more general results arrived at in the investigation :—

(1) A very large amount of heat, sufficient often (if not otherwise absorbed) to heat the air-current to boiling point (212° Fahr.), is always being formed in a mine, and this heat is almost entirely produced by oxidation of material in the mine.

(2) The heat formed greatly exceeds in amount, as a rule, the heat withdrawn by the air-current, so that the temperature of the mine, or of some parts of it, is above that of the strata.

(3) The disappearance of oxygen and liberation of heat in the mine are probably due, largely at least, to oxidation of iron pyrites; and the liberation of carbonic acid in the mine is probably due to the action on carbonates of the sulphuric acid thus formed.

(4) Coal, when exposed to air, absorbs oxygen, and may also give off carbonic acid and fire-damp, and a very small amount of carbonic oxide.

(5) The rate of absorption of oxygen by coal varies directly with the proportion of oxygen present in the air; and as the temperature of the coal increases in arithmetical progression the rate of oxygen-absorption increases in geometrical progression, the ratio of increase (for the coal experimented upon) being about $\frac{1}{10}$ for every 4° Fahr. of increase in temperature.

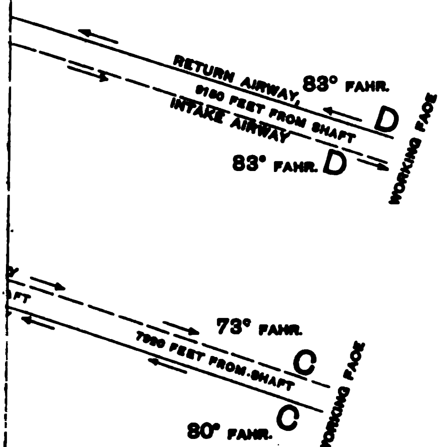
In a future paper, the writers hope to treat the subject of underground temperature and spontaneous fires from the point of view of the health and safety of the men and horses working in the mine. The data which they have collected on these points are, however, still too imperfect to allow of their being advantageously embodied in the present paper.

[The publication of this paper and the further prosecution of the authors' investigations have been delayed by the great fire which unfortunately occurred at Hamstead colliery in November, 1898. The fire broke out unexpectedly, and with extraordinary suddenness, in the main south return airway, close to the pit-bottom, at a place which, when inspected a very short time previously, showed no indication of danger. Apparently a "bump" had suddenly opened up a free air-supply to a hidden break containing heated coal, communicating at one end with the return airway, and at the other with a bolt-hole from the intake airway. The result was that flames rapidly burst into the return airway and fired the road. The ventilating-fan was at once stopped, and the separation-doors between the main north intake and return

airways were thrown open, so as to diminish as far as possible the air-supply to the fire. Every effort was, at the same time, made to dam off the air-supply from behind. These efforts were, however, unsuccessful, as the fire spread backwards against the air-current, and across towards the intake airway, with great rapidity. There was thus no resource left but to seal up the shafts, which was accordingly done with sand and clay after the sumps had been strongly timbered over.

The fire was accompanied by no loss of life or injury. There were about 700 workmen in the pit at the time; and they, along with the horses, were rapidly withdrawn before the fire spread to the main south intake airway. Had the fire or smoke reached this intake airway before their withdrawal, there was still a way of escape open, the north and south workings being connected at the back by a fire emergency road, arranged so that in the event of a fire on either main intake road the men could escape by the other. Under the circumstances, however, it was not necessary to carry out the instructions which had been given that the men should be brought out by this road if smoke were met in the south intake airway.]

Mr. G. L. ADDENBROOKE read the following paper on "The Midland Electric Corporation, Limited," etc.:—



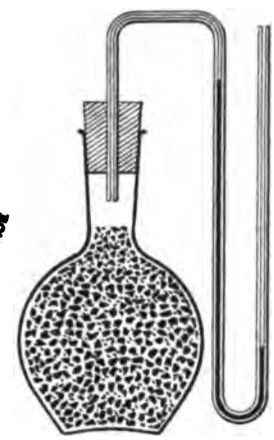


Fig. 3.

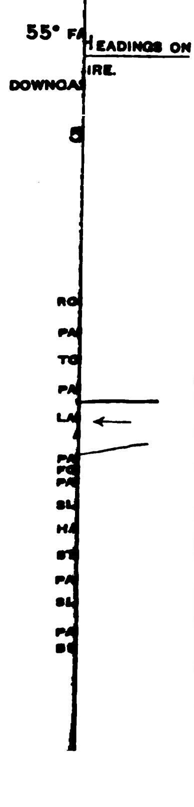
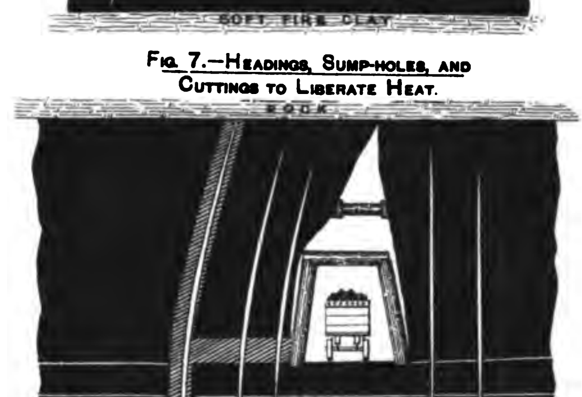


Fig. 6.—Fires in Breaks and Headings for dealing with them.

Fig. 7.—Headings, Sump-holes, and Cuttings to Liberate Heat.



THE MIDLAND ELECTRIC CORPORATION, LIMITED, AND ITS BEARING ON MINING IN THE SOUTH STAFFORDSHIRE DISTRICT.

By G. L. ADDENBROOKE.

Speaking broadly, this paper relates to the steps which are being taken to introduce an electric-supply into the district with the special view of its application to power purposes.

On August 12th, 1898, the royal assent was affixed to a Provisional Order giving the Midland Electric Corporation, Limited, power to supply electricity over the areas of the local authorities of Heath Town, Wednesfield, Short Heath, Bentley, Willenhall, Bilston, Darlaston, Wednesbury, Sedgley, Coseley, Tipton, and Rowley Regis; besides which arrangements are also in progress for taking over the districts of Oldbury and Kingswinford, whose local authorities had obtained their own Provisional Orders. Powers for the supply of electric current are also being sought over the areas of eight other local authorities in the next Session of Parliament.

As regards price, it is one of the objects of the Midland Electric Corporation, Limited, to put the whole district on as nearly the same footing as possible.

The Midland Electric Corporation, Limited, now possess powers of supply over a fairly compact area containing a population of more than 250,000, and if they are successful in their applications this session, additional districts, containing a population of 100,000, will be added to their area. With an area populated by 350,000 inhabitants, the Midland Electric Corporation, Limited, is in a position to supply Dudley (with a population of 45,000), West Bromwich (with a population of 60,000), and Smethwick (with about 40,000) at a cheaper rate than the municipalities could do by erecting their own isolated works.

At a convenient site, a central station will be erected containing a plant of about 5,000 horsepower, with arrangements for extending this power with as little extra trouble as possible. At this station, multiphase current will be generated at from 5,000 to 6,000 volts pressure, and it will be distributed by underground conduits through a network of

cables, which will, as far as possible, be arranged so that each point may be reached from two directions. By this means the current may be cut off in one direction so as to connect another customer, or to effect repairs, without interrupting the continuity of supply.

This multiphase current will be taken to convenient sites in the towns and to any works or mines where power or light are required, and the pressure will there be reduced by transformers to the pressure most suitable for the kind of work for which the current is to be used. This transformed or secondary current, the pressure of which will be below that with which a serious shock can be given, will be led directly to the working points, where motors will be installed, and used for driving in a variety of ways almost any kind of mechanism. Electric motors can be used with economy over separate steam-driven plants, or over the method of using an engine to drive a long line of shafting from which power is taken off at intervals.

The general basis on which the prices have been worked out is in the form of a sliding-scale, on the understanding that equal capital outlay and equal works cost shall as nearly as possible pay the same rates for services of whatever character. Thus a mining-pump working steadily all the 24 hours at the same load would pay the lowest rate. An electric crane or haulage-plant used intermittently and with varying loads for a few hours per diem will pay a higher rate, because it costs more to provide such a plant with current.

In any case, speaking generally, the rates will work out at about 25 per cent. under the cost of steam in the Birmingham district, as at present generally used, with the conveniences and economies of electricity thrown in.

Mr. G. L. Addenbrooke showed upon the screen views of mining and other machinery to which electricity could be applied, together with suitable dynamos and motors, and general views of large central stations.

Votes of thanks were accorded to the authors of the papers, and the meeting then terminated.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD IN THE MASON UNIVERSITY COLLEGE, BIRMINGHAM, DECEMBER 8TH, 1898.

MR. J. LINDOP, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of Council Meetings were read and confirmed.

The following gentlemen were elected :—

MEMBERS—
Mr. JOSEPH MARTIN ALDRIDGE, Walsall.
Mr. BENJAMIN HOUGH, Ruabon.

ASSOCIATE MEMBER—
Mr. C. S. MILLS, Abercrave, Swansea Valley.

STUDENT—
Mr. WILLIAM PARSONS, Halesowen Road, Old Hill.

DISCUSSION ON DR. J. S. HALDANE AND MR. F. G. MEACHEM'S "OBSERVATIONS ON THE RELATION OF UNDERGROUND TEMPERATURE AND SPONTANEOUS FIRES IN THE COAL."*

Dr. J. S. HALDANE briefly recapitulated the conclusions set forth in this paper. He might add that the chief danger of spontaneous combustion in coal-mines was the tremendous suddenness with which fire might break out. The members had a striking instance of this rapidity in the Hamstead disaster.

Mr. J. LINDOP remarked that the recent Hamstead disaster was a serious occurrence, and would have been more serious but for the immediate and well-directed efforts of the management. In such a sudden and extensive disaster it was fortunate that no lives were lost.

Mr. F. G. MEACHEM said that at the outset he must acknowledge the kind expressions of sympathy for the proprietors of the

* *Trans. Inst. M.E.*, vol. xvi., page 457.

Hamstead colliery. The large number of fires at Hamstead colliery all occurred in return air-roads, where the air was warm. In 20,000 feet of return air-roads, no less than 200 fires occurred in 1895, and 295 fires in 1896. The lessons learned from this experience were :—(1) Do not put insets in the Thick coal-seam ; and (2) where possible, there should be at least 8 or 10 times the thickness of the seam between the roads. The spontaneous fires had chiefly taken place where the Thick coal-seam was about 25 feet in thickness. About 90 per cent. of the fires occurred in return air-ways.

Mr. W. B. Scott (H.M. Inspector of Mines) said that there were various points in this important paper upon which further information was required. He wanted, for instance, to know how the heat was distributed to which reference was made in the first conclusion, namely, that "a very large amount of heat, sufficient often to heat the air-current to boiling-point (212° Fahr.), is always being formed in a mine." He had doubts as to the validity of the third conclusion, that the disappearance of oxygen and liberation of heat in the mine were due to the oxidation of iron-pyrites. For 40 years it had been held that the oxidation of coal was the actual cause of underground fires, and that they did not arise from iron-pyrites.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD IN THE MASON UNIVERSITY COLLEGE, BIRMINGHAM, FEBRUARY 2ND, 1899.

MR. JAMES LINDOP, PRESIDENT, IN THE CHAIR.

The Minutes of the last General Meeting and of Council Meetings were read and confirmed.

The following gentlemen were elected :—

MEMBERS—
Mr. G. D. BROWN, Rotherham.
Mr. HAROLD JACKSON, Mining Engineer, Hagley.
Mr. J. B. MOXON, The Beeches, Rugeley.

STUDENT—
Mr. CECIL FEATHERSTONE-WITTY, The Mining School, Camborne.

Mr. F. G. MEACHEM read the following paper on "The Martin and Turnbull System of Water-sprays" :—

THE MARTIN AND TURNBULL SYSTEM OF WATER-SPRAYS.

BY F. G. MEACHEM.

The Martin and Turnbull system of water-sprays for damping dust is extensively adopted in collieries in the South Wales coal-field.* Where compressed air is used for power purposes in the mine the air for the spray-producer is taken from the compressed-air main by ½ inch wrought-iron tubes to the spray-producer, which is generally fixed over the centre of the roadway in the level or heading. A water-main is carried parallel with the air-main, and from it to the spray-producer another ½ inch wrought-iron tube conveys the water. Immediately before entering the spray-producer, the air and water-pipes are united, the air passing through a conical water-nozzle, while the water issues

* *Trans. Inst. M.E.*, vol. xii., pages 411, 413 and 417.

through an annular orifice around the conical water-nozzle, where they are united in one stream on their way to the diffuser or spray-producer. The aerated water in issuing through the narrow adjustable orifice around the circumference of the spray-producer may be reduced to any degree of fineness, from a stream or jet of water, or a mist or fog, to that of invisible vapour—depending upon the width of the orifice and the pressure under which the aerated water issues.

By this system, the exceeding fineness of the spray is such that it is carried by the ventilating-current for long distances into the mine, effectually cooling the air in the mine and damping the dust which lurks in crevices and upon and behind the timber, as well as the roof, sides and floor, without unnecessarily wetting the roads, which so often causes upheaval of the floor of the mine.

A very good spray may be produced through the diffusers by causing water to pass through them under high pressure, without the addition of compressed air, but it is not so effectual as the former method.

At the Ynisybwl colliery, watering is effected by means of hand-jets, and in that case the man has a flexible hose which he attaches to a union-joint on the water-main in the main haulage-roads, and so waters roof, floor and sides every hour of the day. This spraying had the effect of both cooling the air and laying the dust. The manager (Mr. Jenkins) was of opinion that it was almost impossible to have a coal-dust explosion, if this watering were regularly carried out.

At the Llwynypia colliery, fixed water-jets were used. Sometimes they blew from the roof and sometimes from the sides of the road, and were kept constantly flowing. The greatest objection was that the riders taking the journeys of tubs in and out of the workings were constantly wet, otherwise the system was most efficient. The dust was so thick that one could not see clearly a light when 150 feet off, but after the sprays had been running for ½ hour the lights could be seen at distances of 1,000 and 1,500 feet. The lowering of the temperature of the air was notable.

A vote of thanks was accorded to the writer of the paper.

The meeting then terminated.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PAPERS.

EDUCATION OF MINING ENGINEERS.

Die Maschinentechnische Vorbildung der Montaningenieure. By PROF. A. BAUER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv.*, *pages* 168-171.

The present writer is an advocate for practical work, but he considers that theoretical instruction must accompany it. Students cannot be set to test governors, gas or steam-engines, without some previous knowledge, and this must be imparted either orally or by a course of lectures. Can mechanical teaching at mining schools, with its necessary theoretical accompaniment, be expanded in such a way as to render these experiments useful to the student? Or would it be better simply to instruct him how to carry out the trial, just as an ordinary workman is taught to make a chemical analysis? The latter course, if followed, would assuredly prove futile. On the other hand, if the mining engineer is to enjoy a scientific training outside his own special line, and trials of heat-engines are to be added to it, they will alter the curriculum, because they require much time and special knowledge. The question must be decided by the practical necessities of the case.

The engineer of a cotton-mill, for instance, will confine himself to a study of the looms under his charge. If he wishes to test a particular lubricant, it will not be worth his while to make the trial himself, but he will send a sample to a testing-station, where a quicker and better analysis will be carried out by trained experts. In the same way, a mining engineer should test his iron, but trials of the lubricant used, covering of steam-pipes, or action of the governor, should be left to others. Technical schools should be managed on the same practical lines. In the chemical laboratories attached to the mining-schools the pupils do not analyse indiarubber, petroleum, paper, etc., though all these are used in mining. In the same way, they should confine themselves in the mechanical laboratories to what is of importance in their profession, such as the testing of different kinds of iron, to which, in the writer's opinion, they might add a study of steam-engine indicators, and of the tensile strength of materials.

In the Vienna schools, technical drawing forms part of the second year's course, and follows geometry. A preliminary knowledge of the laws of projection is essential, otherwise a draughtsman cannot draw correctly. In Germany, technical drawing is taken in a student's first year, but a knowledge of geometry is presupposed.

Whether the course of study in technical high schools should extend over three or four years is a question often discussed. The writer is of opinion that three years are not sufficient. The hours of study of a third year's student in a German school are: From 8 to 10 a.m., lecture on electro-mechanics; 10 to 12 a.m., lecture

on engines, pumps, fans, etc.: and from 1 to 6 p.m., work on the same subject with the same professor. These hours represent an average sample of the plan of work, but they are certainly too long. In the Austrian mining-schools, the term of study was formerly always four years, and it was not found that a student entered the profession too late. In a technical school, the student should never be overburdened with lectures and preparation, and his studies should be thoroughly and therefore quietly pursued. Time is required to assimilate his knowledge and make himself familiar with the literature of the subject, and this cannot be effected in a hurried three years' course. B. D.

EARTHQUAKE AT SINJ, DALMATIA, 1898.

Vorläufiger Bericht über das Erdbeben von Sinj am 2 Juli, 1898. *By* F. von Kerner. *Verhandlungen der k.k. geologischen Reichsanstalt*, 1898, *pages* 270-276.

This earthquake took place on the morning of July 2nd, 1898, and wrought considerable damage to buildings, etc., in the Sinj or Ravnica plain, and in the area immediately south of it on both banks of the Cetina river. The peripheral zone of feebler intensity was characterized by the limitation of the damage to roofs, some built of thatch, others of badly-laid stone flags. The next zone, going towards the epicentre, was indicated by cracks in the rough-hewn stone walls of the houses and by partial collapse of small cottages. Within the zone of greatest seismic intensity there were wide gaping fissures in the house-walls, and many a cottage was reduced to a mere heap of ruins. This zone includes such villages west of the Cetina as lie along either slope of the divide between the Vojnic and the Ravnica basins. The damage, both in distribution and in kind, was exactly similar to that which is typical of most wellknown earthquakes. Once again, and by abundant examples, the old-established rule was confirmed that buildings erected on loose soil or rubble suffer far more than those founded on solid rock.

Large numbers of pebbles from the alluvial deposits were hurled into the air and showered on the fields around; masses of rock were snapped off from the crags and tumbled into the roads. Cracks and fissures in the ground were observed in several localities along the south-western rim of the Ravnica plain, but the soil, softened by the rainy weather that followed upon the earthquake, soon closed up again. Small circular depressions, too, were formed; and many springs turned muddy, while others fluctuated up and down in their yield of water.

The author gives a detailed description of the geological features of this district, but this can hardly be studied to advantage without the aid of the Austrian Geological Survey map. The strata appear to be chiefly Cretaceous limestones, Nummulitic limestones, marlstones, and breccias, with a vast development of Neogene marls and conglomerates and other Tertiary freshwater beds. Within the area are comprised also the terminal portion of a ridge of Werfen beds (Alpine Trias), and two spurs of Muschelkalk. A review of the tectonic geology of the district shows that we are dealing here with a portion of the earth's crust, which is cut up by a network of faults into a great number of fault-blocks (*schollen* of German-speaking geologists), thrust against each other both horizontally and vertically. The present period of earthquakes, ushered in by premonitory tremors during many previous years, is to be regarded as a new phase of the

"creeps" which have been going on in the fault-block area of Trilj ever since Neogene times; and the immediate cause of the earthquake of July 2nd last is probably a movement of the massif which lies between the radial faults of Košute and Trilj. This is precisely one of those fault-blocks which, as far back as the Neogene, were depressed in relation to their surroundings, and have been subjected to much sagging since then. It appears possible that a slight downward sag of this fault-block, combined with lateral pressure, took place: the amount of thrust varying at the various boundaries. The motion was more or less transmitted to the neighbouring fault-blocks, and they, especially such as lay to the north-west, underwent slight thrust. Yet we are told that the transmitted shocks appeared to have been most violent in the area south of the sagging fault-block. The circumstance that regional depressions were not perceptible at the surface is explained when one bears in mind that the area is covered with a mantle of comparatively recent plastic formations, whereby the step-fault in the underlying rocks will have been masked and smoothed over.

The great majority of descriptions of the main earthquake point to undulatory motion, but in the area of highest seismic intensity one finds also records of an up-and-down movement preceding the wave-motion; and all agree in stating that a great rush of wind and a rumbling noise preceded the earthquake.

The innumerable after-shocks appeared to have been conditioned by the gradual return of the rocks to a state of equilibrium. Thence would ensue thrusts in the neighbouring fault-blocks, and this would explain how it is that some of the after-shocks were more distinctly perceptible away from the epicentral area.

That the movement was easily transmitted along the strike of the beds, there being but few obstacles to check or deflect its course, is clearly shown by the isoseismal curves which have been plotted out. Eastward, the shock appears to have almost died away in the huge alluvial deposits of the Ravnica; and those reports which represent the earthquake as having come from a direction diametrically opposite to the epicentrum, really go to prove that there were reflex waves.

L. L. B.

EARTHQUAKE AT AND NEAR BRÜX, BOHEMIA, 1896.

Bericht über das Erdbeben von Brüx am 3. November, 1896. By Friedrich Becke. *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der kaiserlichen Akademie der Wissenschaften, Wien, 1897, vol. cvi., abtheilung i., pages 46-59, with a map in the text.*

This earthquake occurred shortly after 9 p.m. on November 3rd, 1896, along the slope and crest of the Erzgebirge in the district north-west of Brüx, and the author's description is based on the reports sent in from 14 different localities. Negative evidence, by help of which the limits of the disturbed region may be plotted out, is forthcoming from a great number of Bohemian localities where no shock was observed. The reports are exceptionally trustworthy, as they emanate from the observers appointed by the Earthquake Committee of the Vienna Academy of Sciences; and the scheme of organization adopted by that committee for the accurate observation of seismic phenomena over the whole of the Austrian empire was already in full working order.

The disturbed area is practically elliptical in form, its greater axis extending for about 25 miles from Reitzenhain to Hochpetsch, and its shorter axis for about 13 miles from Görkau to Ossegg. Most of the reports agree in stating that the main shock, accompanied by a rumbling noise like the roll of thunder, was followed a few minutes later by a similar though feebler shock. In the Alexander

pit, at 240 feet below sea-level, the effect was that of a tremendous thump from under the floor of the mine, with a simultaneous shivering motion.

The account from Niedergeorgenthal differs from all the others in recording the occurrence, at 6·30 p.m., of a thrust-movement from south-west to north-east and back again in the space of 2 seconds. Then at 8·55 p.m. took place, from north to south, a second shock, beginning with a noise like thunder, and followed by a subterranean rumbling. Close upon this came a violent shock in a southerly direction, causing a great clatter of glasses, crockery, etc. This was equivalent to the main shock of other localities. The final shock, at 9·10 p.m., was very slight, with a tremulous motion. Looking at the map, Niedergeorgenthal appears to be one of the localities which lie nearest the presumed epicentre.

The direction taken by the earthquake is mostly reported as north and south, but there are many reports giving it as south-east and north-west, while a few from the very edge of the Erzgebirge state the direction variously as east and west, north-east and south-west, or south-east and north-west. No damage to buildings was done, but small objects were displaced, clocks were stopped, stove-pipes, etc., were cracked. In the Trupschitz collieries, timbering was thrust out of place, and there were falls of coal from the roof. In fact, throughout the brown coal-mines of the disturbed area, the earthquake was so distinctly felt that the pitmen fled for their lives, fearing that the workings would fall in and bury them.

It appears evident, however, that the movement had its origin in the basement-rocks of the Erzgebirge, and that the brown coal-basin was only concerned in it secondarily. This view is confirmed by the reports of premonitory tremors, which were felt chiefly in the mountains and in the villages nestling at the base thereof. At Eisenberg, one observer noted no less than 23 such tremors, which he perceived the more distinctly that his dwelling lies in the heart of the forest, far removed from the usual routes of traffic, and from the vibrations naturally associated with them.

Some of the reports mention after-shocks, but the data are not very positive. Several draw attention to the fact that an unusually violent storm was raging at the time of the earthquake, followed by a heavy snowfall. In reference to this, the author supplies a table of barometric observations, taken every 2 hours at Prague, from the 1st to the 6th of November. These show that the preliminary shocks were coincident with a very low barometer, while the main shock occurred with a rising barometer, a few hours later than the registered minimum.

With regard to the geological aspect of the earthquake, Prof. Laube has pointed out that it took place at a point where an anticlinal of basement-gneiss, which farther west forms the southern boundary of the Erzgebirge, is cut off by a fault-fracture striking north and south. Eastward the gneiss-fan is either missing altogether, or present only in fragmentary patches. L. L. B.

EARTHQUAKE IN THE SOUTHERN BÖHMERWALD, BOHEMIA, 1897.

Bericht über das Erdbeben vom 5. *Jänner*, 1897, *im südlichen Böhmerwald. By* Prof. F. Becke. *Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der kaiserlichen Akademie der Wissenschaften, Wien*, 1897, *vol. cvi., abtheilung, i., pages* 103-116, *with a map.*

The district over which the observations extended borders on Bavaria and Upper Austria, and the reports represent the shock as most violent in four localities which lie about a line drawn approximately from north-west to south-east along the first-mentioned frontier. Reports from 30 other Bohemian localities

represent the shock as feeble, from 8 localities as very feeble, while 9 localities, situated approximately on an elliptical curve bounding the area on the Bohemian side, report no shock at all.

The earthquake took place at 7·45 a.m. on January 5th, 1897. It is described as a tremulous vibration, accompanied by a subterranean rumbling very like the muttering of distant thunder or the rolling of a heavy waggon upon a hard road. Some reports compare the sound to the roar heard in a chimney when it is ablaze. In all cases the rumbling was perceived to be simultaneous with the shock, but its duration was greater. Thus it is that in 6 localities observers claim to have heard the sound before, while others assert that it began only with the shock, and continued after it, dying away little by little.

The account given by observers at Innergefild (a "feeble-shock" locality) differs from all the others, which report uniform vibration, in stating that the vibration was an increasing one, terminating with two dull thuds. Two thumps, following close one upon the other, were also reported from Bischofsreuth; while at Winterberg a kind of lateral thrust was felt, coming from below.

The average duration of the tremor was 4½ seconds. With regard to direction, the accounts vary considerably: thus 5 report it as north and south, 6 as north-west and south-east, 5 as north-east and south-west, 1 as east and west, and another as north-north-west and south-south-east. At all events, the majority of the observations go to prove that the Bohemian area was merely a peripheral portion of the actually-disturbed region, and that the epicentrum lay somewhere in Bavaria, to the south or south-west. This assumption is further confirmed by the marked increase in seismic intensity in a south-westerly direction.

A premonitory tremor was noted at Winterberg at 4·25 a.m. on January 5th, and an after-shock at Eleonorenhain at 6·30 p.m. on January 7th.

No damage was done by this earthquake, but it caused some excitement among the inhabitants of the district, as no such event had occurred there within the memory of man.

The map, which accompanies the paper, summarizes by various graphic signs all the main facts gleaned from the reports sent in. L. L. B.

EARTHQUAKE IN TRIPHYLIA, PELOPONNESUS, 1899.

Sur le Tremblement de Terre de Triphylie du 22 *Janvier*, 1899. *By* D. EGINITIS. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1899, *vol. cxxviii., pages* 521-523.

At 9·48 a.m. on January 22nd, 1899, a somewhat violent earthquake occurred in the province of Triphylia, on the western coast of the Peloponnesus. This portion of Greece is frequently visited by earth-tremors, as, for example, the destructive earthquake of 1886.

The earthquake now described consisted of two violent shocks, the first of which was preceded and accompanied by a loud subterranean rumbling. The motion was undulatory, and lasted for 7 seconds. The second shock, following close upon the first, had about the same duration, and was accompanied by a similar rumbling, but the motion was more jerky and caused far greater damage. At the epicentrum, the shock appeared to travel from south-west to north-east, almost at right angles to the major axis of the epicentral ellipse. Prof. Milne's observations at Shide (Isle of Wight) showed that the earthquake travelled to this country at the rate of 1·3 miles per second.

The reports received (on the special observatory forms) from all parts of Greece enabled the author to plot out the isoseismal curves. As usual, these assume an elliptical form, and divide the Peloponnesus into four zones of diminishing intensity. The epicentre was somewhere about Kyparissia, where 53 houses were completely wrecked, 70 rendered uninhabitable, and not a single building remained undamaged. Similar havoc was wrought in the neighbouring villages. At Philiatra, the walls of all the houses were more or less fissured. Curiously enough, no crevices have appeared in the ground in the epicentral zone, but from Kalamata, in the next succeeding zone, small subsidences occurred, damaging the railway-line, and at Janitza a small fissure was observed in the ground. Springs, in various localities, were temporarily stopped or ran muddy. It was noted that before the earthquake, domestic animals, such as chickens and dogs, uttered cries of terror and ran about as if seeking to escape from some invisible danger.

After-shocks of minor importance continued for a whole week, until January 29th, 1899. L. L. B.

EARTHQUAKES IN CENTRAL ITALY.

Periodicità dei Terremoti Adriatico-marchigiani e loro Velocità di Propagazione a piccole Distanze. By ADOLFO CANCANI. *Atti della Reale Accademia dei Lincei, Rendiconti,* 1899, *series* 5, *vol. viii., pages* 76-79.

On September 21st, 1897, took place an earthquake, having its epicentrum in the Adriatic, about 13 miles from the coast, between Fano and Sinigallia. The shocks were very violent, and much damage was done in the towns of Jesi, Pesaro, Sinigallia, Ancona, and the surrounding country. In the present paper, the author refrains, however, from giving the detailed account, which he reserves for the *Bollettino della Società Sismologica Italiana:* his object is to set forth certain important results which may be deduced from the available data.

In the first place, he tabulates all the considerable earthquakes which have occurred during the past thousand years in the provinces of the Marches and Romagna. From this it appears that at intervals of 100 ± 14 years earthquakes have taken place of a mean intensity of 9·1 in the Rossi-Forel scale. These are succeeded at intervals of 23 ± 10 years by earthquakes of intensity 8 in the same scale. The interval between the first series of earthquakes and the second varies between relatively wide limits, considering the length of the interval itself; but the similar intervals between the major earthquakes may be regarded as fairly equal.

In the second place, he draws attention to the velocity of travel of the seismic waves over distances varying from 18¾ to 65½ miles from the epicentrum, in the case of the above-mentioned earthquake of September 21st, 1897 (classed as 7 in the Rossi-Forel scale). It is shown that the speed increased with the distance from 0·53 mile to 2¼ miles per second. The differences are due to the varying intensities of the initial impulses, and above all to the diverse constitution of the rock-formations traversed by the seismic waves. L. L. B.

RECENT EARTHQUAKES IN SWEDEN, 1897-8.

Meddelanden om Jordstötar i Sverige. By E. SVEDMARK. *Geologiska Föreningens i Stockholm Förhandlingar,* 1898, *vol.* xx., *pages* 347-353.

In addition to the considerable earthquake which made itself felt in Scania and Blekinge on January 9th, 1897, two other earthquakes of minor importance were recorded in Sweden during the same year. One took place at 1·30 p.m. on June

16th, in Rackeby parish, in the neighbourhood of Lidköping, and the other on August 4th, at 3 a.m. in the neighbourhood of Uddevalla. Near the last-named town there was a landslip on a hill which stands over against Hagarne, and masses of rock weighing several tons crashed down upon and destroyed a wooden building.

In 1898, earthquakes took place in the provinces of Scania, Northern Bothnia and Western Bothnia, and in the Sundsvall district.

On May 2nd, 1898, between 10·30 and 11 a.m., three distinct shocks were felt at Axelsdahl, parish of Mörarp, Scania. The first was the most violent and was of quite unusual duration; between it and the second there was a lapse of 6 minutes; and between the second and the third an interval of 25 to 30 minutes. The movement seems to have travelled from south-east to north-west: during and after, but not before it, was heard a sound comparable to the noise produced by a heavy-laden waggon rattling over a hard road. A curious point about this earthquake is that persons who happened to be out in the open merely noticed the extraordinary rumbling, but did not feel the vibrations, which were perceived only by persons indoors. Moreover, the tremor was more acutely felt in upper than in lower rooms of dwellings.

On July 4th, 1898, about 10 p.m., two violent shocks, following close one upon the other, were felt at Sundsvall and in the surrounding country. The meagre reports sent in from five localities agree fairly well. After-shocks were recorded at Berghem on July 6th, and at Nianfors on July 8th, 9th and 17th. Mr. P. J. Holmqvist has pointed out that certain disturbances in the Rapakivi series of rocks of this district, which are evidently of quite recent origin, may well have been caused by this earthquake. As a matter of fact, the Sundsvall district is frequently shaken by earth-tremors, which at times attain a high degree of intensity.

The earthquake in Norrbotten and Vesterbotten took place about midnight of the 4th to the 5th of November, 1898, and most of the accounts received from eleven localities at the Central Meteorological Office agree in reporting two shocks. But they do not agree as to the interval between the shocks, which is variously stated as 2, 5 and even 30 minutes. At Pajala, the second shock was much feebler than the first, the motion was undulatory, and travelled from south-east to north-west. A dull rumbling sound both preceded and followed the first shock, which lasted about 1 minute. From Tärändö, the direction of wave-travel was reported as north-west and south-east; from Malmberget, Haparanda, and other localities as west and east; while at Matarengiby it is said to have travelled from north to south.

The author does not report any injury to persons or any serious damage to buildings (with one exception) from the foregoing earthquakes. L. L. B.

PROPAGATION OF EARTH-TREMORS FROM LABUAN, BORNEO.

I Terremoti nell' Isola di Labuan (Borneo), del 21 *Settembre*, 1897. *By* G. AGAMENNONE. *Atti della Reale Accademia dei Lincei, Rendiconti*, 1898, *series* 5, *vol. vii.*, *part* 2, *pages* 155-162.

At about 8·30 p.m. (Central European mean time) on September 20th, 1897, and at 6·30 the next morning, the most delicate instruments in the Batavia and Bombay observatories and in several European observatories were perturbed by seismic waves transmitted over a vast area and lasting over a considerable space of time. These were connected with the sudden emergence of a volcanic island

near Labuan, on the north-western coast of Borneo. The director of the Batavian Observatory, in communicating to the author the particulars noted there, pointed out that the shocks were purely mechanical in character and not magnetic.

Postulating that the epicentrum was not very far off the island of Labuan, in latitude 5° 30′ north and longitude 115° 12′ east of Greenwich, the author calculates a table of velocities and durations, from which it may be seen that the perturbations travelled at rates varying from 10 to 20 miles a second, and lasted from 1 to 4 hours. Comparatively low figures, however, are recorded for Bombay and Edinburgh. The enormous velocities tabulated in the present instance at Rome, Nikolaiev, Potsdam, Shide, etc., differ so strikingly from those registered in the case of the Indian earthquake of June 12th, 1897, that the author seeks for an explanation.

Supposing, in the first place, that the quickest seismic waves (the longitudinal waves in the theory of indefinite elastic bodies) are really propagated along chords instead of along great circles, then the difference in the case under review will be, for European localities, sufficiently considerable. Thus, taking the observatory that is farthest from the epicentrum, namely, Shide, in the Isle of Wight, the arc of the great circle which unites it with Labuan is 7,098 miles long, while the chord is only 6,185 miles in length, shorter, that is, by 913 miles, or about $\frac{1}{8}$ of the arc. Therefore, the apparent velocity of the seismic waves, on the assumption that they travelled along the chord, should be diminished by about $\frac{1}{8}$.

In the second place, the Batavian magnetograph, being much the nearest to the epicentrum of any of the recording-instruments in question, probably began to vibrate during a phase of each perturbation anterior to the commencement of the phase recorded even as near as Bombay. Now, the calculated velocities were based on a comparison of the times registered at the more distant observatories with the times registered at Batavia, and at the moment when the European instruments began to vibrate they were reached by waves of a later phase and of different velocity.

Taking the foregoing explanations into account, the true rate of travel would be $6\frac{1}{4}$ miles per second, which precisely agrees with that recorded for the Indian earthquake.

After discussing more in detail the records obtained in the Italian observatories of the periods of oscillation of the quick waves and the slow waves, the author points out that the velocity of the latter (1·55 to 1·85 miles per second) also agrees with that observed in the case of the Indian earthquake. The exceptionally low figures registered at Edinburgh show that the bifilar pendulum there was unaffected until the more pronounced undulations began—slow waves of great amplitude.

The author lays stress, in conclusion, on the advisability of having in all observatories similar recording-instruments similarly conditioned as regards sensibility. The data would then be much more easily comparable, and would enable one to follow the transformation which each phase of the motion undergoes as it travels onward. The uncertainty induced by confusing the various kinds of seismic waves (of different rates of motion) is much greater, in the case of earthshocks propagated over a great distance, than the error resulting from inaccurate records of the exact time. L. L. B.

EARTHQUAKE IN HAYTI, WEST INDIES, 1897.

Il Terremoto nell' Isola di Haiti (Antille), del 29 Dicembre, 1897. By G. AGAMENNONE. *Atti della Reale Accademia dei Lincei, Rendiconti*, 1898, *series* 5, *vol. vii., part* 2, *pages* 316-318.

At about 6·30 a.m. on December 29th, 1897, an extremely violent shock (9 to 10 in the De Rossi-Forel scale) was felt in the Yaque valley, which runs in the northern part of the island from east-south-east to west-north-west between the mountain-ranges of Cibas and Monte Cristo, the latter of which cuts the valley off from the Atlantic coast.

The effects of the earthquake were most perceptible along the lower course of the Yaque, but they were fortunately not so disastrous as might have been expected, mainly because the habitations are all built of wood. It is calculated that the position of the epicentre was about latitude 19° 30′ north and longitude 71° west of Greenwich. At Santiago, some 20 miles east-south-east of this point, where the buildings are mostly of brick, great damage was done to walls, etc., and several houses had to be pulled down for safety's sake.

The earthquake made itself felt at Port au Prince 105 miles away to the south-west, where a self-registering seismograph gave a remarkable diagram of 90 seconds' duration; and even at Great Turk's Island, more than 125 miles to the northward, the shock though slight was sufficient to stop the clocks. Moreover, seismographs were set vibrating at Toronto, 1,750 miles away, in Ischia and Catania on the Mediterranean, and even as far as Nikolaiev.

The quickest seismic waves travelled to the Italian shores at a speed of about 6½ miles per second. These probably longitudinal undulations were succeeded by the characteristic slow-period waves, those of greatest amplitude travelling at an average speed of 2 miles per second. It is noticeable that the foregoing results agree with the figures obtained for the great Indian earthquake of June 12th, 1897.

There were about forty after-shocks of minor importance, during the space of a month, after which that portion of the earth's crust appears to have resumed its normal equilibrium.

The author proposes to publish a more detailed account of the earthquake in vol. iv. of the *Bollettino della Società Sismologica Italiana.* L. L. B.

FORMATION OF PEAT.

Sur la Constitution des Tourbes. By B. RENAULT. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol. cxxvii., pages* 825-828.

The author describes in some detail the result of his examination of the peat-moss of Fragny, situated east of Autun, at a height of 1,820 feet above sea-level. Among the plants which grow on its surface and swell it with their *débris* are sphagnum moss, sundew, bracken, reeds, grasses, a little gorse, juniper and heather, a few scattered willows, oaks and birches.

The upper peat-layer, of a yellowish-brown colour, is made up of the frequently recognizable *débris* of these plants. The lower layer, black when wet, dark brown when dry, is plastic, greasy to the touch, and stains the fingers: it is made up of *débris* in an extremely fine state of division. After a description of these, the author tabulates the following conclusions:—

1.—The microscopically small *débris* which make up the black peat are the most durable portions of the dead plants, such as cuticle, liber, spores, pollen, vascular framework, etc. The other tissues have been generally destroyed by various agencies; among others, by the action of microbes.

2.—Unlike many lignites, there is no fundamental cementing-matter binding together the constitutents of this vegetable mud. Such matter, consisting of ulmic compounds, is swept away, as soon as formed, in the brown waters which so often ooze out of peat-mosses.

3.—The extremely fine state of division of the organic *débris* may be considered as the outcome of the work of microbes, and this observation also applies to those varieties of coal whose structure exhibits a similar fine state of division.

4.—The wood that occurs in peat-mosses shows from the surface downwards an ever-increasing alteration: the ligneous tissue being permeated with the mycelium of microscopic fungi. Moreover, such wood exhibits curious modifications of protoplasma, and swarms with micrococci, some of which continue in active motion even after being taken out of the peat. L. L. B.

CONSTITUTION OF CANNEL COALS.

Sur la Constitution des Cannels. *By* B. RENAULT. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol. cxxvi.*, *pages* 491-493.

The cannels are of more highly diversified microscopic structure than the bogheads, and may be divided into three principal classes. (1) Those containing a number of yellow bodies, chiefly microspores and macrospores, with but few algæ. To this category belong the cannels of Lesmahagow, Bryant, Burghley, Cannelton, Ceberga, and Rive de Gier. (2) Those containing organized-matter—pollen-grains, spores and macrospores—mixed with fragments of plant-remains. Example: Commentry cannel. (3) Those consisting of completely dissociated organic elements; *e.g.*, Buena Vista cannel.

The author examined Bryant cannel—under a power of 1,200 diameters—and discovered in the yellow matter of which about one-third of the total mass consists:—

(1) Spherical macrospores, 340*u* in diameter, with enlargements bounding the lines of dehiscence, and with their surfaces furrowed by micrococci.

(2) Smaller macrospores: some measuring 41*u*, pitted with dark cavities (1·3*u* in diameter) and containing micrococci (diameter 0·5*u*); others 48*u* in diameter, and covered with tiny spikes.

(3) Reticulated macrospores 44*u* in diameter, resembling the calcified *Sphenophyllum* of Rive de Gier.

(4) Sub-triangular forms (rare), 33*u* broad, with enlargements edging the intra-radial space. When open, the aperture exhibits a crown of micrococci.

(5) Micro-pores, constituting about four-fifths of the total yellow matter, mostly isolated and triangular, measuring 46*u* by 33*u*, but sometimes forming tetrads 64*u* in diameter. These and the macrospores (No. 1) recall those of Lepidodendra and other arborescent Lycopods, and may possibly have been derived therefrom.

(6) A small number of algæ, originally globular, but now flattened and hollow, measuring 45*u* by 25*u*. They are young Pilas (probably *Pilax Scotica*) and are filled with micrococci.

(7) The foregoing organisms are infested in many places with the mycelia of thread fungi in the matrix, the filaments being straight or sinuous, single or branched. Short spurs bearing conidia are found on the branches; the individual cells of the latter measure 2·9*u* by 0·85*u*. In growing, the filament on entering the envelope of the invaded structure, throws out a branch which splits into two dichotome twigs 2*u* by 0·8*u*, bearing conidia 0·8*u* to 1*u* in diameter. The whole plant is about 6*u* long and resembles a minute *Botrytis Carnea;* the author names it *Anthrocomyces cannellensis*. It is frequent in Moscow cannel-bogheads, Armadale boghead, etc. C. S.

CANNEL COAL IN BOHEMIA, AUSTRIA.

Die Cannelkohle des Steinkohlenbergbaues Heinrichsglück-Zeche in Peterswald. By RICHARD DANILOF. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1897, *vol. xlv., pages* 467-469.

Cannel coal has been discovered in the Heinrichsglück pit at Peterswald, in the centre of the Ostrau-Karwin mining district of Bohemia, and is found in conjunction with hard bituminous coal. The strata consist of sandstone, sandy slate and shale, between which the seams of coal, varying in thickness from less than 1 inch to nearly 7 feet, are embedded. The Coal-measures are overlain by Tertiary rocks and diluvium. The seams form a deep depression running in a south-westerly direction, and cut in two by a wedge-shaped cleft. Here a fault occurs, and the northern part of the seam is thrown up nearly 200 feet above the corresponding southern portion, which alone retains its original position, and where the cannel coal occurs, none having been found in the northern division. The seam varies from 4 feet to nearly 7 feet in thickness, and is inclined . t a slight angle. The roof and floor are shale, beyond which is sandstone, and *Sigillaria*, *Calamites*, and numerous other species of fossil flora and fauna have been found in both divisions of the seam. The cannel coal, which near the fault forms the whole thickness of the seam, thins off, and at last wholly disappears, giving place to ordinary bituminous coal. Near the fault, the seam is about 4 feet thick; the upper part is pure cannel, then a thin band of coarse-grained mineral streaked with cannel, and lastly a second bed of cannel coal. This lower stratum is the first to disappear, but the ordinary and cannel coal are mixed for a considerable distance.

The seam is intersected by two sets of fissures, mostly filled with white calcite and pyrites. One series of fissures runs parallel to the strata, and appears to have been produced during the formation of the coal; the other is vertical, at right angles to the seam, and probably owes its origin to shrinkage.

The cannel coal is of a greyish hue, with dull brown streaks, of low specific gravity, and very firm and tough. Fractured surfaces show a smooth glitter like ebony. It contains much bituminous matter, and chips of it can be easily kindled with a match.

The writer is of opinion that cannel, like every other kind of coal, is of vegetable origin, and that the bitumen it contains is due, not to animal remains, but to plants rich in resin. This he ascribes to the fact that, during the time the cannel coal was formed, no animals probably existed that could have imparted the large percentage of bitumen found in it. B. D.

MOSAIC-PAVING, BOHEMIA.

Die Mittelböhmische Mosaikpflaster-Industrie. By DR. FRIEDRICH KATZER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1897, *vol. xlv., pages* 210-214 *and* 224-226.

"Red marble," so-called, from Sliwenetz, was used in Prague for water-pipes about 50 years ago. When discarded for cast-iron, the marble pipes were broken up for small paving-stones, and answered the purpose so well that this limestone has long been regularly quarried at Sliwenetz and elsewhere in the Palæozoic mountains, near Prague.

All the work is piecework. Formerly, a quarryman was paid from 1s. 3d. to 1s. 8d. for filling a truck 2 feet square and 1 foot high, now, not more than half that price is given. To make this mosaic paving, black, red and white limestones of the Lower Devonian formation are used, and the manufacture is now practically the monopoly of a large firm in Prague. The black limestone is easily worked, and a skilful quarryman can fill from 5 to 10 trucks per day, while not more than 2 trucks per day can be filled with the granular red and white limestone, and there is more waste with the latter.

As all stone used for mosaic paving must possess elasticity, durability and beauty of appearance, the writer tested Bohemian limestones for these qualities. To determine their compressive strength or elasticity, a vertical hydraulic press was used, and cubes of the three kinds of limestone were tested dry, and after soaking 2 days and boiling in water. The results are given in a table in the original paper. Their elasticity was found to vary greatly, partly owing to the organic remains which abound in these limestones. The elasticity of the red and white limestones was increased by soaking in water, and that of the coarser grained black limestone was diminished.

As the wear of footpaths is chiefly caused by the tread of feet, the stone was tested on a grindstone, and with a boring-tool. The grinding-machine had a treadle, and a horizontal rotating-stone upon which a surface of 5¼ square inches of the sample was exposed, and continuously moistened with water. Each sample was 13 cubic inches, and the loss by volume after 300 revolutions of the wheel was 8·6 per cent. with black limestone, 11·6 per cent. with red limestone, and 15 per cent. with white limestone. With Bohemian granite, the loss was 4·3 per cent. Therefore to use black and white, or black and red limestone together for mosaic paving, when exposed to much wear, is not desirable, as the flooring will soon become uneven. For the boring tests, a vertical machine was used, the borings were collected, weighed, and the loss in weight determined. The samples were of the same size as before. For the same number of revolutions of the drill, the black limestone lost 2·45 per cent., the red limestone 2·83 per cent., and the white limestone 2·97 per cent., while the loss with granite was 1·66 per cent.

The durability of the stone, that is, its resistance to the effects of the air, atmospheric deposits, as snow, rain, and hail, changes of temperature and rays of the sun, was next considered. As these subtle meteorological influences do not affect the "life" of paving-stones as much as the wear of traffic, the writer studied only the most important, namely, the disintegration produced by frost. This is much influenced by the capacity of the stone for absorbing moisture, since the destructive power of the water while freezing is the greater, the more porous the stone. Black limestone was found to absorb 3·1 per cent., red limestone 3·5 per cent., and white limestone 3·3 per cent. of its weight of water, after soaking for 2 days. The limestone was also frozen in a refrigerator. Samples of the same size

as before were used, and were frozen and thawed 3 times. After being frozen twice, the black limestone began to split, and crumbled and scaled at the edges. The red limestone showed signs of disintegration after being frozen once, while the white only began to break up after being 4 times frozen. The loss in weight was 8·6 per cent. of the black limestone, 11·1 per cent. of the red limestone, and 6·1 per cent. of the white limestone. The loss in consistency of a stone when exposed to frost has a most important effect on its durability, and this was estimated at 31 per cent. with black limestone, 23 per cent. with red limestone, and 26 per cent. with the white limestone.

The third requisite in paving-stones intended for ornamental purposes is beauty of appearance, and in this respect the Bohemian mosaics compare favourably with others. The black and red limestones lose their colour a little when exposed to the air, but the contrast is always pleasing, and is more striking when they are combined with the white limestone. Full details of the various tests and instruments used will be found in the original paper, but there are no drawings.

B. D.

PYRITES-DEPOSITS OF SCHMÖLLNITZ, HUNGARY.

Der Schwefelkiesbergbau der Oberungarischen Berg- und Hüttenwerks-Actien-Gesellschaft bei Schmöllnitz im Zipser Comitat. By BERGREFERENDAR FÄHNDRICH. *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate*, 1898, *vol.* x*lvi.*, *pages* 217-234, *and plate XII.*

Overlying the crystalline schists, which between Kaschau and Neusohl strike east and west, parallel with the main axis of the Carpathians, is a series of varicoloured Devonian (?) metamorphic schists and schistose limestones, interbedded locally with a dark green to black "gabbro" (as, for instance, between Dobschau and Kotterbach). The ore-deposits of Upper Hungary are in such immediate topographical relationship with this gabbro, that some observers have sought to establish a causal relation between the outburst of that eruptive rock and the occurrence of the ores, an hypothesis which the author holds to be "not proven."

In the counties of Zips, Gömör, and Abaujvar, within the area of metamorphic rocks, bounded to the northward and southward by Carboniferous Limestones, four parallel belts of ore-deposits may be traced over a length of 40 miles, ranging east and west between Dobschau and Kaschau. In the northernmost belt, the ores appear to be interbedded with the Devonian (?) chloritoid-schists, but the author agrees with Mr. Faller in considering the ores of that particular belt as true vein-deposits. They have a steep southerly dip (70° to 85°); they do not invariably coincide with the bedding; the gangue sometimes includes masses of the country-rock, is generally coarsely crystalline, and is separated from the "country" by a narrow argillaceous salband. The average thickness of this deposit is 10 to 13 feet, but largely owing to the above-mentioned inclusion of masses of "country" it sometimes attains a thickness of 146 feet. It consists in part of spathose iron-ore, in part of copper pyrites and fahlore: repeatedly associated with these are various ores of mercury and nickel, and antimony-glance. Iron pyrites is a constant associate, but lead and zinc-ores are extremely scarce.

The next belt to the southward, ranging westward from beyond Rosenau to Aranyidka in Abaujvar county, consists mainly of antimony-ores associated with metamorphic clay-slates (which deep down pass into gneiss), striking north and south with a westerly dip. As these ore-deposits cut across the strata, a

over contain many drusy minerals, no hesitation has been felt in regarding them as true veins. Seven great veins are recognized, dipping steeply southward. The gangue, 6½ to 10 feet thick, is made up of clay-slate fragments, quartz, spathose iron, bitterspar, calcspar, argentiferous antimony-glance, zinc-blende, auriferous pyrites, etc.

The third belt is formed by the iron and copper pyrites-deposits of Schmöllnitz, in Zips county, which will presently be considered in greater detail.

The fourth belt, south of Schmöllnitz, includes spathose iron-ore, associated with quartz, fahlores, and copper pyrites. These deposits closely resemble, in both their mineralogical and geological aspects, the bedded veins of the first belt. Their occurrence does not seem to be confined to the Devonian series, for immediately south of Schmöllnitz they also appear within the area of crystalline schists.

Turning now to the Schmöllnitz deposits, which are in every respect different from all the others, they chiefly occur along the valley of that name, which is a lateral tributary of the Göllnitz valley. It is shut in by high hills, the Rothenberg and the Spitzenberg, and here the ore-deposits form a series of irregular lenticles, associated with a zone of greyish-green Archæan sericite-schists, metamorphosed by the irruption of diabase or gabbro. These schists sometimes pass, with gradual diminution of the sericite, into quartz-schists. At both walls, the ore-deposit is bounded by a 40 feet belt of dark grey to black phyllites, wherein carbonaceous or graphitic particles lie thickly scattered. Outside these come the light-coloured quartz-schists, which south of Schmöllnitz include the spathose iron and chalcopyrite-deposits of the fourth belt. These quartz-schists, on the footwall side, are broken through by a complex of rocks consisting mainly of crystalline limestones. Dr. Steinhausz attaches considerable significance, from the point of view of the genesis of the ore-deposits, to the occurrence of a mass of diorite or diabase a few hundred feet vertically below them, and always in those areas where the deposits are richest.

In the main, the Schmöllnitz deposits form three reefs, known respectively as the Top, Middle and Bottom reef, each varying in thickness from 3½ to 58 feet, and traceable along the strike for 2 or 3 miles. They have been proved to a depth of 1,170 feet by means of 8 drifts and deep levels. On the whole, these reefs are singularly conformable with the sericite-schists, but sometimes they bifurcate, owing to the alternate nipping-out and wedging-in of the intermediate barren schists. In reality, no sharp dividing-line can be drawn between the reef with its rich lenticles (made up of coarsely granular iron pyrites and chalcopyrite so intimately commingled as to be undistinguishable by the naked eye) and the "country," impregnated with pyrites in an excessively fine state of division. The author quotes the following chemical analysis of the ore from Dr. Steinhausz's memoir:—Sulphur, 47·89 per cent.; iron, 45·31; copper, 0·46;* lead, 0·33; zinc, 0·37; arsenic, 0·55; antimony, 0·06; bismuth, 0·03; nickel and cobalt, traces; manganese, traces; lime, 0·03; magnesia, 0·05; residue insoluble in acids, 4·89; total, 99·97 per cent. He compares with it no less than 14 analyses of Spanish, Norwegian, and German pyrites, which tend to show that in chemical and mineralogical composition the Schmöllnitz pyrites approaches most nearly the Spanish, except in the percentage of copper: therein the Norwegian comes midway between the poorer Hungarian and the richer Spanish ores. Regarding the origin of the Schmöllnitz deposits, the author agrees with Messrs. Von Cotta and Hauch that it is purely sedimentary, and sets forth at length the reasons for dissenting in this case from Messrs. Vogt and Steinhausz's "vein-theory."

* Unusually low: the average variation is 0·5 to 2 per cent.

The working of ores in this area, from the days in the far-off 13th century, when the Kings of Hungary, by charters and royal deeds of gift, made over fiefs and mining rights to the Saxon immigrants, has a long and chequered history down to our own times. There have been many changes of ownership, many transitions from prosperity to adversity and back again, in the course of six centuries. In 1890, the Hungarian State transferred its property in the then long decaying mines to a limited company, for a consideration of 1,000,000 florins (say £85,000). Up to the early seventies all efforts had been centred on the production of copper, but with the exhaustion of the rich copper-ores and the accumulation of enormous waste-heaps of pyrites, attention began to be directed to the utilization of the latter on a large scale, and a new era dawned on the mining industry of the region. Sulphuric acid is now the ultimate product sought for, 1 to 3 per cent. of copper is got by the wet way out of the pyrites, and the residue yields 60 to 65 per cent. of an iron-ore which is found especially suitable for the manufacture of Bessemer pig and for consumption in puddling-furnaces. The production increased from 38,388 metric tons in 1890 to 58,610 metric tons in 1894, while in the same period the number of workpeople employed about the mines rose from 300 to 450.

At present, the fresh pyrites is being worked chiefly in the deeper portion of the deposits, and care is naturally taken to use for packing and stowing, as far as possible, waste which is free from pyrites, or even stone brought from neighbouring quarries. In the upper levels a productive "aftermath" is still reaped from the waste discarded by the old miners.

The temperature in the mines, owing to the continual oxidation of the pyrites, is very high, ranging from 35° to 50° centigrade (95° to 122° Fahr.), being highest in the neighbourhood of old workings or where the incursion of surface-waters favours rapid decomposition. A partial remedy is applied in the shape of constant spraying of both the working-faces and the packing with cold water. Nevertheless, the temperature sometimes rises sufficiently to ignite the timber left in the packing. Fires, therefore, are of frequent occurrence, and they can only be fought by the extension of the watering system.

Copper is separated by the cementation process on the mine itself, and the pyrites is sorted, according to size and quality, into nine different varieties (cubes, nuts, peas, dust, etc.). It is then loaded direct into trucks on the light railway to Göllnitz, whence it is carried to the company's sulphuric-acid works at Budapest and Sillin.

The paper is preceded by what appears to be an exhaustive bibliography of the subject. L. L. B.

MINERAL INDUSTRIES IN THE ZALATNA-PRESZÁK DISTRICT, TRANSYLVANIA.

Geologische Verhältnisse des vom Zalatna-Preszákaer Abschnitte des Ompolythales nördlich gelegenen Gebietes. By ALEXANDER GESELL. *Jahresbericht der Königlich Ungarisch geologischen Anstalt für* 1896 [1898], *pages* 156-164.

The author's personal observations appear to be confined to the roofing-slates, which form a belt about ½ mile in width, beginning in the Bibarcz valley, and extending thence to the Fenes valley and beyond. Their coloration is bluish, greenish-grey, and red, and they can be split into slabs as thin as ⅛ inch (about 3 millimetres). Experts have pronounced them very nearly as good as the slates which come from Wales and from France; they admit of being bored and sawn through, and their behaviour in regard to change of temperature is perfectly satis-

factory. These roofing-slates are associated with sandstones and marl-slates, all of which are probably of early Tertiary age. The roofing-slate industry would be a new one in Hungary, and on the condition of applying competent technical knowledge and sufficient capital, the prospects before it are very good.

The remainder of the paper is a summary of the information culled from the Budapest and Hermannstadt archives, regarding the mining of gold, silver, and mercury in this district in former times. L. L. B.

RECENT BORINGS FOR COAL IN THE NORTH OF FRANCE.

Résultats des récents Sondages pour la Recherche de la Houille dans le Nord de la France. By J. GOSSELET. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol. cxxvii.*, *pages* 162-165.

The series of borings made in the North of France, with the view of proving the prolongation of the great Franco-Belgian coal-field, were brought to a close in July, 1898: the last syndicate, which had held out as a forlorn hope, then finally relinquishing the search.

As long ago as 1860, the author had proved that the Coal-measures of Hardinghem and Ferques in Boulonnais were really the continuation of the Franco-Belgian basin, and he was of opinion that the Carboniferous Limestone and Devonian shales which outcrop south of those two localities form an anticlinal fold dipping southward beneath yet another coal-basin.

The five borings of La Liane were put down, so as to strike this hypothetical coal-field. Of these, three – at Menneville, Bournonville, and Wirvigne, passing through Jurassic rocks, reached shales which strikingly resemble the Lower Coal-measures. At Liévin and Drocourt, similar shales had just been found, overthrust on to the Coal-measures; but, although the above-mentioned three borings were carried on with great perseverance, they never got out of the barren shales. The fourth boring, at Samer, south of these localities, struck the Gedinnian – a horizon which, from Aix-la-Chapelle in the east to Bristol in the west, invariably occurs outside the boundaries of the true coal-field. The fifth boring, near Le Waast, struck the Upper Devonian, after passing through 314 feet of shales, which were at first regarded as Lower Coal-measures, but now prove to be Silurian.

While these borings were in progress, news came of the discovery of the Dover coal-field, and several French syndicates began to search for its continuation on the other side of the Channel. Eleven borings were put down in French Flanders, in the departments of the Nord and Pas de Calais. Four of these alone reached the Palæozoic rocks, and then only struck Silurian—a result which brought about the speedy abandonment of the other seven borings.

The author, in correlating the Dover coal-field with the Franco-Belgian basin, had pointed out that the latter is probably thrown out northward, to the west of Ferques, and that its main axis probably passes somewhere between Wissant and Calais. This hypothesis was shown to be correct by a boring put down at Strouane, on the western flank of Cape Blanc Nez, which, after striking three well-marked coal-seams, passed into Devonian shales. Thereupon, borings were multiplied around Wissant, and they struck mostly Carboniferous Limestone, Devonian shales, and Silurian rocks. It is plain that the Wissant Coal-measures are a mere remnant, perhaps a transported remnant (by dislocation or thrust), of the great coal-basin, and that it would not pay to work them.

Now, all the foregoing explorations had been made either north or south of the Jurassic anticlinal of Lower Boulonnais. It seems well nigh certain that this anticlinal corresponds to a Silurian plateau, and that there is no hope of finding coal underneath it. Thus, a boring, put down in the corresponding synclinal at Wimereux, struck Silurian rocks at 1,440 feet, and another at Framzelle struck the same rocks at almost exactly the same depth. In contrast with the results recorded in Lower Boulonnais is the discovery, by the engineers of the Liévin collieries, of black calcareous shales of Wenlock (Upper Silurian) age, beneath which lies workable coal-seams.* The author believes that these Wenlock shales are the beginning of the Silurian massif which spreads out in Lower Boulonnais.

L. L. B. and C. S.

IRON-ORES OF BRAY, FRANCE.

Sur l'Origine du Minerai de Fer hydroxydé du Néocomien moyen du Bray, par l'Altération superficielle du Fer carbonaté, et sur la Continuité en Profondeur et l'Importance du Minerai carbonaté. By N. DE MERCEY. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol. cxxvii., pages* 1245-1248.

In the course of researches made in 1897, the author traced a number of old slag-heaps, and proved by means of shallow borings that iron-ore is present from one end to the other of the Pays de Bray, in widely scattered but very numerous deposits. Having thus ascertained that the occurrence of the limonite or brown hæmatite is not, as had previously been imagined, a mere local phenomenon, the author conducted a series of deeper borings, whereby it was shown that in depth the oxides passed into sphærosiderite or clay-ironstone, more or less compact, concretionary, or Oolitic. The harder and denser the ore, the richer it proves to be, the average tenour ranging between 30 and 40 per cent.

The carbonated ore really occurs in several continuous bands intercalated amid sands and clays of Middle Neocomian age, forming a regular succession rather more than 80 feet in thickness, and there is no such confusion or irregularity as had been postulated. Several artesian wells have been put down recently in the neighbourhood, and the records obtained from them entirely confirm the author's conclusions. These wells go right through the Lower Neocomian sands and refractory clays and reach the Upper Portlandian rocks.

It was only the superficial zone, where the original ore has been decomposed to limonite by the oxygenated waters percolating down to the general water-level of the country, that was worked in former times. As to the origin of the carbonated ore, the author does not regard it as an intermediate phase in the decomposition of iron sulphides; rather does he believe that it was chemically precipitated from waters charged with iron and full of rotting plant-remains.

The high dip of the Middle Neocomian strata in the Pays de Bray will necessitate extensive pumping operatious before the actual working of the deep ore-deposits can be started.

In discussing this paper, Mr. de Lapparent pointed out that a similar passage of iron-oxides into carbonate, from the surface downwards, had been observed in the Oolitic rocks of Lorraine and in the lowermost Ordovician beds of Normandy.

L. L. B.

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* *Trans. Inst. M.E.*, vol. iii., page 1028.

BLACK PHOSPHATE OF LIME IN THE PYRENEES, FRANCE.

Sur les Phosphates noirs des Pyrénées. By DAVID LEVAT. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol. cxxvii., pages* 834-836.

The author's attention was first called to these deposits in May, 1898, 20 miles south of Oloron in the Lower Pyrenees. Since then he has traced them eastward and northward into Languedoc, in the departments of Ariège, Haute-Garonne, Aude, and Tarn.

Their stratigraphical position is in the Upper Devonian, at the junction between the Griotte marble and the overlying Carboniferous or Permian shales. They form a regular bed no less than 26 and often as much as 32 feet thick, and are of a lustrous black, reminding the observer of anthracite and smutting the fingers. Hence they have been miscalled "impure anthracite," "graphite-beds," etc. In its richer portions, the bed is characterized by the presence of flattened nodules, hard, black, and shiny: these consist of nearly pure phosphate of lime; the assays showing 62 to 77 per cent. of tribasic phosphate. The nodules are generally grouped either at the floor or at the roof of the bed, and the enveloping "gangue" is itself phosphatized. Moreover, the latter contains an enormous quantity of organic material, yielding no less than 0·3 to 0·5 per cent. of organic nitrogen. After sorting out the rich nodules, the residue still contains 14 to 16 per cent. of phosphoric acid, which makes it very suitable for agricultural purposes.

The fact that the bed continues to be rich in phosphate down to great depths has been proved by the workings in the manganese-mine of Las Cabesses, where the nodule-layer is exposed in a level at 370 feet below the surface.

The Picardy phosphates, which are in pockets (in the Chalk) and the Quercy phosphorites, which form groups of veins, are occurrences essentially different from that above described.

The industrial value of these Pyrenean phosphates depends almost entirely on the question of means of transport, and on the greater or less proximity of railways.

L. L. B.

PROSPECTING IN SAVOY, FRANCE.

Explorations Minières dans les Alpes. By ALBERT BORDEAUX. *Revue Universelle des Mines, etc.*, 1898, *vol xliii., pages* 1-43.

In Savoy, as in the Alps, the mineral deposits occur either in the crystalline or in anthraciferous rocks; but there are deposits of iron-ore in the Upper Jurassic and Lower Cretaceous series.

Iron enters into the composition of numerous rocks in the crystalline masses; and other metals are chromium, aluminium, titanium, and manganese. Numerous veins of quartz traversing these rocks are sterile; but sometimes they contain oligist iron, blende, galena, pyrites and grey copper, with occasionally asbestos, epidote, stilbite, wavellite, molybdenite and corundum. One of the smallest crystalline masses, at Rocherai-en-Maurienne, contains so many minerals that it has been called a mineral cabinet.

The anthraciferous rocks comprise argillaceous shales with mica and talc, quartzose sandstones and siliceous conglomerates with Coal-measure fossils and beds of anthracite. The anthraciferous schists have undergone a metamorphism

which appears to be due to heat; but Mr. Michel Lévy considers that the lamination of the schists must rather be attributed to a kind of metamorphism, while there is a gradual transition from schists and sandstones to porphyries and quartzites. The argillaceous shales are generally in non-concordant stratification with the crystalline shales, the aspect of which they sometime assume however; and these shales contain quartzose and pyritous veins with numerous anthracite-seams. The most important zone of anthraciferous measures in Savoy follows, on the south-east, the zone of the crystalline rocks, leaving an interval occupied by Lias. The schists are especially metamorphosed on the north-east, where they can with difficulty be distinguished from crystalline shales; but they contain quartz and gneiss-pebbles. The anthracite-seams in this zone are much faulted; and of the numerous metalliferous veins the most important are those of lead and zinc at Mâcot and Pesey, at which latter place, at an altitude of 5,000 feet, a school of mines was founded in 1802. Deposits of argentiferous lead occur in the Val Montjoie, of copper at Beaufort, of lead and copper at Bonvillard and Montchabert, and of iron and copper at Saint-Georges d'Hurtières.

The anthraciferous rocks form, in Savoy, a belt, parallel with the crystalline rocks, extending from the south-west to the north-east; and another belt follows the north-eastern edge of the crystalline rocks. This last-named belt contains the Servoz argentiferous lead-mines; and the main belt (wherein chiefly occur the richest mines of lead and silver in Savoy), those of Mâcot and Pesey, Du Sault and Des Sarrasins, near Modane. Iron is found in the Montagne des Sarrasins, and along the crystalline rocks from Montpascal to Montgirod and Bourg Saint-Maurice.

Near the Franco-Italian frontier, between Tignes and Bonneval, the crystalline rocks form a long belt parallel with the axial line of the Alps, passing by Aosta, Mont Cervin, Monte Rosa and the Saint-Gothard, and contain many quartz veins, some mineralized, most frequently by pyrites alone, and occasionally by auriferous pyrites. The best known of the auriferous pyrites veins occur in the Bernese Alps; and from south-west to north-east are met with in succession those of Ceres, Pratiglione, Ceresole, Brissogna, Val Tournanche, Val Gressoney, Val Sesia, Val Anzaska and Val Vedro, while the St. Gothard tunnel intersected veins of auriferous quartz. The most important mines are those of the Val Anzaska, namely, Pestarena and Val Toppa, which in 1883 produced 7,000 ounces (200 kilogrammes) of gold, with 300 men, and 6,000 ounces (170 kilogrammes) in 1890, a figure which has been maintained in more recent years.

The author cites, as an example of ancient gold-mining in the Alps, the Goldberg, near Rauris and Gastein, which is situated in the same geological series and under similar conditions as the above-named. At one time the production exceeded 35,000 ounces of gold per annum; and the plans that have been preserved show the existence of 19 miles (30 kilometres) of galleries, and 2 miles (3 kilometres) of winzes. About 800,000 tons of ore, containing at least 0·90 ounce (25 grammes) per ton, have been extracted from the Goldberg, while more than double that quantity, though of less than half that content remains unwrought, to say nothing of the rich pillars below the level of 7,700 feet (2,340 metres). As the deposit does not vary for a vertical height of 1,300 feet (400 metres), it probably continues for a greater depth; and the project has been formed of driving a drift 1¼ miles (2 kilometres) long, at the level of 5,300 feet (1,600 metres), so as to take advantage of an almost vertical escarpment.

J. W. P.

THE IRON-PISOLITES OF THE KRESSENBERG, BAVARIA.

Zur Geologie der Eisenoolithe-führenden Eocänschichten am Kressenberg in Bayern. By OTTO M. REIS. *Geognostische Jahreshefte*, 1897, *vol. x., pages* 24-49, *and plates I. and II.*

These early Eocene pisolites form a comparatively narrow belt, wedged in between the Flysch on the south and the later Tertiary Molasse on the north, ranging, not without interruptions, from Mattsee to Sonthofen. The ore has been largely worked, and more especially in the Kressenberg and Grunten districts. Part of the Kressenberg field has been abandoned since 1881, but the eastern portion is still worked. The deposits are classed as "black seams" and "red seams," according to the degree of oxidation of the iron in the pisolite: apart from this, the origin of the seams is manifestly identical.

The assumption which formerly held good, that one is dealing here with a vast thickness of strata, is now disproved, and it is shown that in reality the same seams are repeated over and over again by folding and faulting. The author discusses the tectonic structure of the area in some detail, and considers that the original surface of deposition has been packed by the processes of mountain-building into a disproportionately small space. Therein the black seams mark the close of the epoch of iron-ore deposition, and the advent of the limestone-facies, characterized by such nummulites as *N. complanatus*.

Comparing and summarizing similar evidence from Switzerland, it appears that the relics of the Alpine Eocene sea bed are still found clinging here and there to the northern margin of the Alps, in sufficient mass to allow of the identification of littoral and shallow-water shell-beds, of pelagic sands and glauconites, while the iron-pisolites occupy exactly the middle position between the shallow and deep-water formations.

The sharp division between the sands, glauconites, and iron-ores is a striking example of the differentiation of clastic sediments according to the specific gravity of their constituents. Not, however, on the hypothesis that the lightest particles have been carried farthest, but that only the very strongest currents had sufficient impetus to sweep the heavy particles away from their original source, and then, as the current now and again slackened, these particles would fall to the bottom. The specific gravity of the iron-pisolites varies from 3·6 to 4, while that of the sands is 2·6, and of the glauconites 2·6 to 2·9. The coarsest siliceous particles are mostly found in the red seams: fossils occur both in these and the black seams, stained of the colour of the ferruginous cementing-material. Some of the fossils show no alteration beyond this staining, while others are completely infilled with iron-ore, and form the nuclei of pisolites. The unaltered fossils belong to a fauna entirely distinct from the encrusted fossils, which, indeed, show unmistakable signs of fracture and corrosion anterior to the pisolitic encrustation. Rock-fragments and nodules occur with these, which have undergone the same process, and it is evident that all the corroded and subsequently encrusted material is derived from the underlying strata. This corrosion, in part perhaps the work of the ocean-surf beating on the old Vindelican shore, and in part that of atmospheric agencies, seems to point to a slow uprise of the sea-bottom, interrupted by periods of depression, during which powerful currents swept off the pisolitic and encrusted material to its present resting-place.

Now, the frequency of these changes of level, if it does not actually justify the hypothesis of eruptive or volcanic phenomena, at least implies a state of disturbance, one resultant of which would be the outburst of thermal springs.

Such springs may well have been the original factory of the pisolites and the associated processes of encrustation The deep-lying granites and gneisses of the old Vindelican continent would furnish little lime, but, on the other hand, abundance of carbonated iron-oxides.

Another circumstance which encourages the belief that the origin of the pisolite is inseparable from the near neighbourhood of an ancient land-surface, is the association, with the so-called "black seams" of the middle group, of miniature coal-seams, resin, and asphalt; while, in the black seams themselves, fragments of worm-eaten wood, and remains of turtles and crocodiles are not uncommon.

It is plain, therefore, that the origin of these iron-pisolites is far from being exclusively marine. On the other hand, the highly-oxidized condition of the outermost crusts in the grains of the red pisolite, and of the iron in the cementing-material of the same, bears testimony to the influence of the excess of oxygen present in the waters of the open sea.

The author is entirely opposed to the hypothesis that the iron-pisolites are merely a result of the alteration of calcitic or arragonitic Oolites, and points out that such an hypothesis was clearly shown to be untenable in the case of the Clinton pisolitic ores by Mr. H. Smith. He then discusses in detail the formation and nature of the beds which overlie the iron-pisolites, and the tectonic processes to which they have been subjected. From the industrial point of view, the importance of these considerations is that they furnish a solution of the problem as to whether there is an extension of the ore-deposits under the Molasse. Such an extension is highly improbable, and, even where beneath the Molasse sunken blocks of Eocene strata may occur, it is almost certain that the ore-beds would be found only at a great depth and much broken up. Another point is that the varying colour of the seams, due to their particular degree of oxidation, is to some extent a guide as to the probable existence or absence of ore-deposits north and south of those at present known and worked. L. L. B.

THE IRON-ORE DEPOSITS OF STAHLBERG-KLINGE, THURINGIA, GERMANY.

Die Lagerstätten der Stahlberger und Klinger Störung im Thüringer Wald. By HANS MENTZEL. *Zeitschrift für praktische Geologie*, 1898, *pages* 273-278, *with a map and three sections in the text.*

The area with which this paper deals is a portion of the south-western slope of the Thuringian Forest, extending from Beierode in the north-west to the Schmalkalde valley in the south-east, and is disturbed by the system of faults and fissures which on all sides demarcate the physiographical boundary of the forest.

The basement-rocks are crystalline, consisting of gneisses, mica-schists, and granite-porphyries, seamed by dykes of melaphyre, syenite-porphyry, etc. Immediately overlying these is the Zechstein Series (Permian), and above this comes the Lower Bunter Sandstone (Triassic).

Taking the chief localities in the same order as the author, we come first to:—

1. *Stahlberg.*—Here the deposit of brown iron-ore extends with a west-south-western strike for about 4,800 feet along the slope of the hill, and is extremely irregular in form, rather of the nature of a "pipe." Seven headings have been driven in it, and several cross-cuts. The ore may be regarded as a metasomatic replacement of limestone and dolomite, by the agency of waters circulating among

the many fissures in this disturbed massif. Some of the fissures are filled with heavyspar, and in many places the actual passage of the dolomite into the iron-ore may be traced. The character of the ore, moreover, varies according to the character of the dolomite which it replaces. Typical dolomite gives place to crystalline spathose iron-ore which, by loss of carbonic acid and oxidation in presence of water, is altered into pseudomorphous brown iron-ore. Dolomite with aluminous or clayey constituents is replaced by a clayey ochreous iron-ore, while the marlstone interbedded with the dolomites does not appear to have been susceptible of metasomatic replacement.

2. *Mommel.*—Here, as in the preceding occurrence, brown iron-ore is associated with heavyspar, while fluorspar also makes its appearance. This deposit comes to day along its whole length, from Herges, north-west of the Stahlberg, to Sandberg, near Beierode, and continues in depth lower down than exploration-work has yet reached. It is limited by two faults, which appear to enclose a sunken (and overturned) trough of rocks whose greatest breadth, 227 feet, is attained in the Kochenfeld district. As these faults run together, near Sandberg, they nip out the deposit by their convergence.

The author describes some other deposits of minor importance connected with the Stahlberg disturbance, and then goes on to speak of:—

3. *Klinge.*—This disturbance consists, like that of the Stahlberg, of a system of faults, while it possesses in common with the Mommel occurrence the peculiarity that the ore-deposits are an alteration-band in a troughed and faulted wedge of dolomite. The workings are in part opencast, in part drifts. The dolomite shows no sign of bedding, is wedged in among gneiss, and is altered in the space between two broad fissures. The ore is mostly brecciiform, and some of it is pulverulent or "pappy."

In conclusion, the author points out that the fissures which have split the rocks in this region are of Oligocene age, and therefore that the alteration of the dolomite into brown iron-ore must have taken place between Oligocene and recent times. Waters containing carbonated oxides of iron in solution are even now percolating through the rocks, as is evident from the existence of the Liebenstein spring. The resulting iron-ores are valuable for metallurgical purposes, because of their invariably high percentage of manganese and their freedom from phosphorus.

As to the origin of the iron-ore, this appears to have been furnished by the clays, shales, and sandstones which lay stratigraphically below the dolomite, and have been largely swept away by erosion. The barium for the heavyspar doubtless came from the felspars of the crystalline rocks, while the presence of sulphated solutions is indicated by the occurrence of gypsum in the Upper Zechstein near Beierode. L. L. B.

GRAPHITE-DEPOSITS OF THE COTTIAN ALPS, PIEDMONT.

I Giacimenti di Grafite delle Alpi Cozie. By V. Novarese. *Bollettino del R. Comitato geologico d'Italia,* 1898, *vol. xxix., pages* 4-36, *and map.*

Although the detailed survey of the Cottian Alps, now approaching its completion, will, undoubtedly, necessitate some changes in the older classification of the rocks, one may, for practical purposes, adhere meanwhile to that of Dr. Gastaldi. He recognized in the great series of crystalline schists two divisions: an upper, essentially calcareo-phyllitic, with enormous intercalations of *roccie verdi* (serpentines, etc. ?); and a lower, consisting essentially of gneisses and

mica-schists. The graphite-bearing rocks are confined to this latter division, near the base of which they occur in their most characteristic facies, their occurrences higher up in the division being mainly of a sporadic and accidental nature.

Beginning at Cumiana in the Northern Cottians, the graphite-belt continues unbroken to the heights which dominate the right bank of the Pellice: interrupted thereafter by the Quaternary strata of the Barge basin, it assumes more the aspect of a series of enormous stratified lenticles of graphitic schists enveloped in ordinary mica-schists and gneisses, but its horizon in the series is unchanged. The gneisses, sometimes white, but more often grey with graphite-pigment, are made up of very minute constituents and poor in mica: here and there are seen gneissose conglomerates, where, in the fine-grained, dark grey, gneissic matrix, parallel lines of fragments of various rocks, but chiefly quartz, appear laminated and squeezed out into fusiform shapes. It seems probable that these rocks are merely the metamorphic phase of a sandstone which had an argillaceous-siliceous cement.

Unlike the gneissose rocks, the mica-schists are very varied in aspect. Sometimes they are ordinary white mica-schists, sometimes they are visibly garnetiferous, or again they are characterized both by garnets and chloritoids. Then there are the spotted schists, with elongated white flecks consisting of a mixture of micaceous minerals and chloritoid; and the ampelitic schists, black, and more or less carbonaceous.

To most of these types there corresponds exactly a graphite-bearing rock, distinguishable, too, by its poverty in quartz, the most widespread of all being the lead-coloured garnetiferous graphite-schist, wherein the garnets range in size from microscopic dimensions to $\frac{1}{3}$ inch in diameter. Quartzites play a very subordinate part in all this group: as a matter of fact, they may be regarded in this case as quartzitic schists extremely poor in mica, but they are sometimes associated with conglomerates of a quartzose character.

The breadth of the graphitic belt varies considerably. In the northernmost part, near Giaveno, it is 1,000 to 1,300 feet broad; in the valley of the Chisone, where various southern offshoots coalesce with the main belt, the width is much greater; and it reaches its maximum in the middle and lower valley of the Chisone and the Germanasca, where it is no less than $2\frac{1}{2}$ miles wide. At the lower end of Val Pellice the breadth is much less, and gradually diminishes as one proceeds southward.

The author considers that there can be no doubt as to the sedimentary origin of the graphite-deposits, the presence of such markedly clastic rocks as conglomerates being sufficient evidence—and the whole series forms, in his view, a normal succession of strata which have been metamorphosed into crystalline schists. They are in every respect comparable with those formations wherein shales and sandstones alternate with beds and lenticles of coal or lignite; and the change from coal into graphite is analogous to the change from sandstone into gneiss and from shale into mica-schist. The very fact that among the graphites themselves there are such differences observable as between graphites proper and graphitites or graphitoids, the result of differences in degree of metamorphism, appears to him an additional proof of the hypothesis.

With regard to the age of the graphites negative evidence only is forthcoming. In the Western Alps, the one formation which contains fossil fuel is the Carboniferous, and this (in the shape of anthracite) occurs in beds and lenticles, the lie and facies of which recall irresistibly those of the Pinerolo graphite. The analogy is still more perfect when the Cottian graphite-deposits are compared with the fossiliferous graphite-basin of Styria.

The graphites which are worked in the Pinerolo district under review have all the properties characteristic of the typical mineral: they have a fine black colour, semi-metallic lustre, they are soft and more or less unctuous according to their greater or less purity, the purest being the least lustrous. On combustion they leave a siliceous ash, with mere traces of iron. The schistose material is so intimately intermixed with the graphite that it is practically impossible to enrich the poorer grades by any mechanical process of sorting or separation. Few assays have been made by the mine-owners, and their methods of working are, in many cases, still incredibly primitive. However, the author groups such as have been published, in a table, together with assays made from his own and other specimens in the laboratory of the Italian Geological Survey. This table shows a percentage of carbon varying from 10 to 85, and a specific gravity of 2·25 to 2·38.

Mining operations were begun on a small scale in the Pinerolo district somewhere between 1835 and 1860, and the graphite was at first extracted (apparently for the purpose of evading the provisions of the Mining Code) under the name of "black earth," and classified as colouring-matter It was not until 1886 that the graphite-workings were properly classified, and from that time up to the commencement of 1898 eleven new concessions were registered. The statistics of production are nevertheless unreliable: year after year the Custom House returns show that Italy exports graphite in greater quantity than the entire declared produce of her mines, and the author estimates the true average annual production at 4,000 tons.

The mines in active work are practically restricted to the region comprised betwen the rivers Chisone and Pellice: thus 9 out of the 11 above-mentioned properties are in the lower basin of the former river, and of these the 5 largest are in the Pramollo valley, a right-bank tributary of the Chisone. On the left bank, the graphitic schists crop out over and over again, but no mining-claims have been registered here, although it is precisely the area where the abuse of illegal excavations for "black earth" has been most rampant. The two remaining claims were declared in 1897, in the hills on the left bank of the Pellice, near the point where it debouches into the plain.

The beds of graphite dip generally southward, sometimes westward, at high angles: never less than 30 degrees, and often as much as 75 degrees; but the strike varies considerably. In some of the mines there are as many as three workable beds, one above the other, and the thickness varies from bed to bed (or sometimes within the same bed) from a few inches to 10 feet or more. Taking into account the fact that this is an Alpine region, the mines are situated at a very moderate altitude, all lying between 2,000 and 2,300 feet above the sea, the Siassera mine alone reaching the 3,100 feet contour. The long Alpine winter, with its heavy snows, does not therefore interfere with graphite-mining operations. When one adds to this the neighbourhood of the plains, assuring easy means of transit, the great extent of the outcrop, the solidity of the country-rock (in regard to roof and floor), and the facility with which waste water can be drained off in hilly ground, it will be understood how for 35 years or more an industry has prospered, which, up till quite recently, was carried on in the most primitive fashion. For a long period, the graphite was worked in each locality by the inhabitants when they happened to have nought else to do, at seasons of the year when labour in the fields was slack. As the shallow excavations went deeper, however, the need of practised hands became imperative, and thanks to an influx of such men from the mines of Sardinia and elsewhere, proper methods of exploration and winning, regular working, and improved transport from each mine to the nearest road, have gradually extended, despite the absence of qualified technical

management. This want makes itself felt, however, in the treatment and sale of the graphite. The raw material is sent direct from the mine to the mill without undergoing any selective process, and there, after having been crushed, it is packed straight into boxes or sacks, with the result that might be predicted: low prices, lower than those of any known graphite in the trade. An Italian metallurgist, who has experimented with it in the manufacture of crucibles, puts the percentage of pure mineral at 61, the value at the mine being 15s. to 19s. per ton, and at Pinerolo, packed, and loaded on to the railway truck, about 38s. per ton.

In addition to the table of analyses, a bibliographical list and the official statistics of graphite-production in, and graphite-exports from, Italy during the years 1860 to 1896 (both inclusive) accompany this exhaustive memoir.

L. L. B.

PETROLEUM IN CENTRAL ITALY.

Sul recente Rinvenimento di abbondanti Fonti Petroleifere a Salsomaggiore. By T. TARAMELLI. *Rendiconti del Reale Istituto Lombardo*, 1897, *series* 2, *vol. xxx. pages* 786-796.

At Salsomaggiore, a thermal resort in the Parmese Appennines, a deep well has been lately sunk to a depth of 2,010 feet, yielding water highly charged with chlorides, iodides, gases, and varying quantities of petroleum. Moreover, a large excavation (some 40 feet deep) has been made near the Baths, laying bare a considerable surface of the salt-marl, which is one of the characteristic strata of the neighbourhood. Through fissures in this marl come up brine-springs, charged with "petroleum," which, after exposure to the air, solidifies into a mineral wax. Those fissures are richest in petroleum which strike north-eastward and dip southward, both strike and dip being inverse to those of the strata themselves. The marl is overlain by breccia and underlain by Eocene limestones and "rough" clays.

The author's interpretation of the stratigraphical conditions is that we have here a group of petroliferous fissures confined to a belt which coincides with a fractured anticlinal—these conditions, according to Prof. Sterry Hunt, indicating that favourable results would attend a systematic search for petroleum.

East and west of Salsomaggiore, a number of wells have been sunk, all yielding brine and hydrocarbons. The Trionfo well, near Scipione, was started in 1884, reaching a depth of 475 feet, and the strata yielded oil more abundantly, according as the proportion of sand in the marl increased. In one month, 540 barrels of oil were got from that well, but by 1885 the output had dropped to 2 barrels *per diem*. Subsequently, other wells sunk to greater depths produced 8 and 10 barrels of oil *per diem*, as long as the supply lasted. Precise data concerning the wells which are now in yield are not available. The author points out that no attempt has been made as yet to tap what he regards as the most promising area for petroliferous fissures, where the dip of the Miocene marls is suddenly reversed.

He gives, in conclusion, some account of the oil-wells at Velleja, in the neighbouring province of Piacenza, a few miles to the westward. Here, a great "boom" in oil-production began in 1890, and, up to the end of 1894, fifty-two wells were sunk, thirteen of which were unproductive and five others were soon exhausted. Production was still increasing in 1895, the daily output for each well varying from 13 to 484 gallons. The syndicate who work the field were proposing to bore to the depth of 2,600 feet, when they hoped to strike what they regard as the primary source of the oil, the deposits hitherto tapped being in their view merely of secondary origin.

L. L. B.

PUMICE OF MONTE PELATO, LIPARI ISLANDS, ITALY.

Von den äolischen Inseln. *By* ALFRED BERGEAT. *Zeitschrift für praktische Geologie*, 1899, *pages* 43-47.

Monte Pelato or Campo Bianco is an extinct crater, whereon the accumulations of pumice reach in places a thickness of 650 feet, and form the chief article of export of Lipari. In point of fact, only a relatively small portion of the pumice is of commercial value, and, all the good surface-deposits having been worked out, the material is now got from extremely primitive underground workings. The small landowners carry on simultaneously the cultivation of the vine above ground and the digging for pumice below. Timber being dear, nothing is done to prevent the workings from falling in, and therefore a certain number of fatal accidents occur every year. About 1,200 persons are engaged in this industry in 120 small mines, two-thirds of the last-named belonging to the commune and one-third to private owners. The annual production averages 6,000 metric tons, of an estimated value of £40,000. There is a local tax of 15s. on every ton produced. Prices vary according to quality, the average being £5 5s. per metric ton at Lipari. The *fiore* or "flower of pumice," the very finest quality, costs ten times that amount, but is of extremely rare occurrence.

Much damage was done to the trade by the action of a syndicate a few years ago. They worked the mines in a reckless fashion, indulging in over-production to the extent of five times the legitimate demand, bankruptcy following as a matter of course.

Most of the pumice is shipped from Canneto, on the eastern coast of the island.

The author devotes some attention to the history of the production of boracic acid, alum, and sulphur on Vulcano, an industry now defunct. But he points out the extreme interest, in connexion with the theories as to the origin of the stanniferous deposits of Saxony and Cornwall, which attaches to the study of the fumarole-products of Vulcano and the high silica-percentage of its lavas. The fumaroles yielded 21 out of the 24 chemical elements and compounds characteristic of stanniferous deposits. L. L. B.

MANGANESE-DEPOSITS OF CHIATUR, CAUCASUS.

Note sur les Gisements de Manganèse de Tchiatour, Caucase. *By* A. POURCEL. *Annales des Mines*, 1898, *series* 9, *vol. xiii.*, *pages* 664-675, *with a rough map in the text.*

The village of Chiatur communicates, by means of a narrow-gauge railway some 20 miles long, with the main line from Tiflis to Batum and Poti. It lies on the banks of the torrential Kviril, in the government of Kutaïs, and in its immediate neighbourhood are clustered the manganese-mines.

The ore-deposit forms a regular bed, showing as a black streak along the mountain-sides, barely interrupted by small faults, and having a northerly dip of only 2 to 5 degrees, increasing at some points to 15 degrees. Below it are the Nummulitic (Eocene) rocks, while above it comes a great series of strata of Sarmatic (Miocene) age: fossil fishes belonging to passage-beds being found in the roof or hanging-wall. The deposit ranges in thickness from 5 to 6½, and even up to 8 feet: it thins out to nothing in every direction, extending about 6 miles down the Kviril valley and about 4 miles across the valley. Northward it is barred by andesitic rocks, the eruption of which is perhaps not unconnected with the origin of the metal. The estimated quantity of ore in the field is 100,000,000 metric tons.

The deposit is believed to have been formed in a shallow sea, and consists of a pisolitic peroxide of manganese, the pisolites increasing in size from top to bottom of the bed. There are marly intercalations, and, near the bottom, gritty bands gradually passing into barren rock. Near the top, on the other hand, the ore becomes clayey and passes into hydrated oxides which are nevertheless still very rich in manganese. The miners persistently reject all the soft stuff, among it being thick masses of friable pyrolusite which yields as much as 52 per cent. of manganese: they regard as true ore only the hard portions of the deposit. Phosphorus is present only in very minute quantities, the average percentage ranging from 0·02 to 0·05, and but rarely reaching 0·15.

Although both British and French companies have started mining in this district, the methods of working are still very primitive. Nor is there any immediate hope of improvement, as local conditions, among which may be mentioned the extreme subdivision of property, make it almost impossible for any one person or syndicate to acquire enough land to set up a modern plant on a large scale. More than a third of the pure ore is left in the shape of pillars, the timbering is perfunctory, and falls of roof are frequent. The workpeople are mainly Imeretians, unreliable, inexperienced, and ill-fed. The ore is loaded into paniers, which are carried by ponies down the steep, badly-kept bridlepaths to the railway-line. Freights as far as Sharopan (the junction) are high, but thence to Poti more reasonable: f.o.b. at that port, the ore costs 20 kopecks per poud (say £1 10s. per ton). The paper concludes with a detail of the costs (at the mine and at Marseilles) and a table of chemical analyses made at the St. Petersburg School of Mines.

L. L. B.

PLATINUM DEPOSITS IN THE URALS, RUSSIA.

Die Platinlagerstätten im Ural. By A. Saytzeff. Tomsk, 1898, and *Zeitschrift für praktische Geologie*, 1898, *pages* 395-398.

This pamphlet contains the results of the author's investigations in the year 1897, the object of which was to discover primary deposits of platinum; his studies were chiefly confined to the Goroblagodatsk and Bissersk district; these are respectively the first and third on the list of platinum-producing areas, that of Nishni-Tagilsk occupying the second place. The deposits of platinum-bearing gravels, typically developed in the valley of the River Iss, show the following section in descending order: Peat; brown generally sandy clay, beneath which a bluish-grey tough clay often occurs; below this come river-sand and gravels without platinum; sand without pebbles is known as *sèwun*, gravel as *retschnik*, this latter often carrying boulders of quartz, and, in the bottom layers, of the bedrock of the district. The platiniferous sand often contains numerous fragments of dark grey rocks and layers of variously coloured clays; the lower portion of the sands is often difficult to distinguish from the decomposed bedrock beneath.

The rocks that form the matrix of the platinum have been found to be olivine-rocks (peridotite and olivenite), porphyrite, gabbro-diorite and syenite-gneiss; all these rocks are in various stages of decomposition, schistose, shattered or containing secondary minerals. Rocks consisting of partially serpentinized olivenite containing bunches and disseminated grains of chromite were found to carry platinum in visible grainlets; an assay gave 0·0107 per cent. of platinum. Porphyrites and gabbro-diorites have also been proved to contain minutely disseminated platinum, but its existence does not seem to have been demonstrated in the syenitic gneiss.

H. L.

IRON-ORE DEPOSITS OF CENTRAL SWEDEN.

Ueber einige Mittelschwedische Eisenerzlagerstätten. By R. Beck. *Zeitschrift für praktische Geologie*, 1899, *pages* 1-10, *with 5 figures in the text.*

The author visited the most important mining districts of Central Sweden in the summer of 1898, and he describes them in the following order:—

1. *Norberg.*—In the parishes of Norberg and Westanfors in Westmanland, 200 iron-mines are dotted along a belt some 12 miles long and 2 miles wide, in the midst of fine-grained gneisses (granulites and eurites of Swedish geologists). Three varieties of iron-ore are worked in this area, namely (1) crystalline iron-glance interlaminated with thin flakes of quartzite; (2) finely crystalline magnetite, intimately associated with garnet-pyroxene rock (*skarn* of Scandinavian geologists); and (3) manganiferous magnetite, occurring in lenticles amid dolomites and limestones. With the last-named ore, pyrites is frequently intermingled, and sometimes galena and chalcopyrite are associated with it in payable quantities, as, for example, at the Kallmora Silfvergrufva. The author's study of this deposit leads him to the conclusion that magnetite and garnet are the oldest constituents, while the ores of lead, copper, arsenic, and fluorspar, calcspar, and asphalt were of later introduction, consequent on tectonic disturbances. No fewer than 94 of the Norberg mines are managed by one company, employing about 450 persons, with headquarters at Kärrgrufvan, on a line of railway.

2. *Persberg.*—These iron-mines are situated in undulating country, on a peninsula which juts out into Lake Yngen. in the province of Wermland. Magnetite alone is worked in this district: it contains on an average 0·002 per cent. of phosphorus, the maximum being 0·013 per cent. The percentage of manganese varies between 0·2 and 0·35, and that of metallic iron between 53 and 60. The ore occurs in extremely irregular lenticles embedded in a garnet-epidote *skarn*, sometimes in the immediate vicinity of masses of crystalline limestone and dolomite, and sometimes folded in with the fine-grained gneisses (granulites). In many places, the ore passes gradually into the garnet-pyroxene rock; and similarly, by following up pyroxene-bands in the granulite, a passage from this into the *skarn* has been observed.

3. *Dannemora.*—Situated on the shores of Lake Gruben, near the railway from Upsala to Gefle, these famous mines have been worked since 1532. The ore is an extremely compact magnetite, yielding on an average 50 per cent. of metallic iron. Across a great spread of granite runs a thick belt of hälleflinta, granulite and manganiferous crystalline limestone. Interbedded with the limestone, or lying between it and the hälleflinta are three series of ore-lenticles, striking north-northeast and south-south-west, and dipping 75 to 80 degrees north-westward. As at Kallmora in Norberg, there are in the Dannemora field instances of the association of pyrites, chalcopyrite, galena, blende, mispickel, etc. with the magnetite, in such wise as to make it abundantly evident that those sulphides are of much later introduction than the other constituents of the deposit.

4. *Grängesberg* in Dalecarlia is nowadays the most important of all the iron-mining districts of Central Sweden; its production of 630,000 metric tons in 1897 exceeded even that of the Gellivara district. For two centuries, the high percentage of phosphorus in the ore constituted an insurmountable obstacle to its working on a large scale, but after the introduction of the Thomas process there was an advance by leaps and bounds in the mining industry of Grängesberg. Four great companies, working in agreement, control the entire field, and most of the ore is shipped at Oxelösund for Rotterdam and Stettin, whence it finds its way to the Westphalian and Silesian blast-furnaces.

The mining-field covers a comparatively small area, 3 miles long and ¾ mile broad, in which the predominant rock is a fine-grained biotite-gneiss. Interbedded with this is a pinkish gneissose granite, at the hanging-wall of which the chief ore-deposits occur. All the rocks strike north-north-east, and dip sharply east-south-eastward.

In the western portion, the Lomberg, Ormberg, and Risberg mines work a great number of small deposits of iron-glance associated with magnetite, and containing from 0·02 to 0·8 per cent. of phosphorus. In the eastern portion, in the so-called "Export" field, two great lenticular masses are worked. The southernmost of these consists of fine-grained crystalline magnetite, containing 0·7 to 1·2 per cent. of phosphorus, and yielding 60 to 62 per cent. of metallic iron. The northernmost, at the Sjustjernberg, consists (near its hanging-wall) of magnetite, with which so much apatite is associated that the percentage of phosphorus reaches a maximum of 2·8; near the footwall it consists of iron-glance with 0·5 to 2 per cent. of phosphorus. Pegmatite veins in some cases course through the deposits, the effect of their passage being to alter the iron-glance into magnetite.

The Norra Hammar mines work a magnetic ore so intermingled with apatite as to contain 6 to 8 per cent. of phosphorus. The "country" in this case is a hornblende-gneiss streaked with highly micaceous bands.

As to the genetic relationship of the foregoing deposits, the author considers that the magnetite and iron-glance crystallized out simultaneously with the constituents of the country-rock; but, at Norra Hammar, the apatite and titanite separated out earlier than the hornblende, which was followed by quartz (in scant measure) and fluorspar.

The deposits have been proved, in one case, to a depth of nearly 1,000 feet, and the amount of ore in sight will take many years to exhaust.

5. *Långban.*—These manganese and iron-ore deposits occur north of Filipstad in Wermland, in association with a belt of dolomite which strikes north and south through a granulite-inlier isolated amid an enormous spread of granite. The manganese-ores (braunite and hausmannite) contain up to 45 and 47 per cent. of manganese: the iron-ore is mostly iron-glance, and, in a very subsidiary degree, magnetite.

Attention is directed to the remarkable occurrence of "native lead" in fissures of the hausmannite-dolomite. L. L. B.

ARGENTIFEROUS DEPOSITS IN THE PROVINCE OF MADRID, SPAIN.

Nota sobre algunos Criaderos argentíferos de los Términos de La Acebeda y Robregordo en la Provincia de Madrid. By R. SANCHEZ LOZANO. *Boletín de la Comisión del Mapa geológico de España,* 1893, *series* 2, *vol. iii., pages* 151-164, *with a plan in the text.*

The area dealt with in this paper lies in the northernmost portion of the province of Madrid, in a country of hill and forest, 56 miles distant from that city, near the watershed between Douro and Tagus. It lies west of the village of Robregordo, on the high road to Burgos, and extends eastward to La Acebeda, at a height of 3,580 feet above sea-level. Halfway between these two villages are the four abandoned mines of Maria Josefa, San Antonio, Virgen del Carmen, and San Francisco, covering a superficies of 135 acres. The author gives a careful description of the workings, into all of which he went, as far as the obstructing *débris* and the water would allow.

The predominant rocks of the district belong to the crystalline-schist series, being chiefly gneisses and mica-schists, with occasional beds of quartzite. Going

southward, the crystalline schists are seen to rest upon granite, while eastward, they are overlain by the Cambrian, and this again by the Silurian. The Silurian formation extends right through the province of Guadalajara; and there, in an inlier of crystalline schists, occur the wellknown argentiferous veins of Hiendelaencina. Moreover, the nodular and macliferous gneisses with large felspar-crystals, characteristic of that area, are equally characteristic of the Acebeda district—the country-rock is in both cases the same. In a general way, the crystalline schists dip eastward at varying angles, and are seamed in various directions by quartz-veins, mineralized with iron pyrites, spathose iron-ore, and argentiferous ores. Native silver is so minutely commingled with the vein-quartz that often its presence cannot be discerned by the unaided eye: where richest, it imparts to the quartz a grey tinge, which darkens on wetting. The chemical combination wherein the precious metal occurs most commonly hereabouts is the sulpharsenate of silver. Marcasite, mispickel, and the oxides of iron (which redden the quartz in places) are frequent associates: they form bands parallel with the grey silver-quartz, sometimes in immediate contact with it, and sometimes parted from it by a band of white quartz. The thickness of the actually metalliferous portions of the veins ranges up to 10 inches, but the distribution of the ore throughout the complex of veins appears to be very irregular (and this is confirmed by the analogous occurrences of Hiendelaencina), so that no reliable inference can be drawn as to the richness of the deposits from their aspect at any particular point.

A table of assays, some of which date from 1853, and others are quite recent, shows that the percentage of silver varies from 0·125 to 1·25.

Unlike other metalliferous regions of the peninsula, no mining-exploration of any importance seems to have been attempted in this district until past the middle of the present century. Then, in the late fifties, there arose a "mining boom" in Spain, and a company was formed to work the deposits. Four shafts were put down, and a heading was driven 350 feet long at a locality known as El Carcabón. The shafts are now full of water and *débris*, but the sole reason assigned for the abandonment of these workings is the financial collapse which followed close upon the "boom," and hurried mining companies, good and bad alike, into bankruptcy.

In view of a possible resumption of mining-industry in this area, the author points out that the new railway from Madrid to Santoña will pass through it, and that only 16 miles east, as the crow flies, from Robregordo, there are small outliers of Coal-measures (east of Tamajon, in the province of Guadalajara) which would doubtless furnish sufficient fuel for local consumption in the mines. Moreover, there are peat-deposits among the neighbouring hills, and the forests would furnish pit-props and charcoal, as well as firewood. L. L. B.

GOLD-BEARING DISTRICTS OF EASTERN BOKHARA, CENTRAL ASIA.

Mittheilungen über das Ost-bokharische Goldgebiet. By ALBRECHT VON KRAFFT. *Zeitschrift für praktische Geologie*, 1899, *pages* 37-43, *with a map in the text.*

In the summer of 1898 the author, as member of an expedition starting from Bremen, found the opportunity of visiting an auriferous region which is all but unknown in Europe. In the neighbourhood of the upper course of the Amu Daria or Pandj, which divides Bokhara from Afghanistan, in the provinces of Baljuan and Darvas, run a series of ridges of early Tertiary gold-bearing

conglomerates, whose elements are mainly derived from crystalline rocks. These conglomerates, which are distinctly bedded, form mountains running up to the level of 13,000 feet, closing in deep narrow valleys whose floor is 5,200 feet or more below the mountain-tops. In other districts, however, the conglomerates are made up of softer materials, bedding is obliterated, the hills are rounded, and the valleys broad. Nevertheless, these rocks reach an altitude of 11,300 feet or more. They are associated with evidently contemporaneous sandstones and marls, and at Kängurt (in the west of Baljuan) the bright red sandstones are seen to rest upon Cretaceous limestones. Below and to the eastward of the Khob Rabat Pass, conglomerates showing no stratification overlie the crystalline rocks. Some 40 miles south-west of the pass, in the neighbourhood of Mount Khasret-i-Shan, bedded conglomerates with a low north-westerly dip are faulted down against vertical red sandstones, shales, and limestones of Lower Triassic age.

The rocks whose *débris* go to make up the above-mentioned conglomerates are predominantly green diabase-tuffs and red felsite-porphyries with irregular druses infilled by calcspar. Red and grey granites, diorites, porphyrites, gneisses, etc., also occur. In size the pebbles average that of a man's fist, but here and there huge blocks with a cubical content of 35 to 70 feet are found. The cementing-material of the conglomerates, partly calcareous, partly sandy, is gold-bearing; so too are the sands of the rivers which flow through the conglomerate-region. The gold occurs solely in the form of thin flakes, it is never granular, nor have any nuggets been found. It assays to 92·7 per cent. The Russian engineer, Pokorski, informed the author that auriferous quartz-veins course through the crystalline-rocks in the immediate vicinity of the conglomerate-region, and such veins are doubtless the primary source of all the gold that occurs in Eastern Bokhara.

Traces of ancient opencast workings and enormous waste-heaps are of frequent occurrence, and it is seen how the inhabitants of the country gradually abandoned gold-mining proper to betake themselves to gold-washing, which is alone practised nowadays. The sands washed by the natives (Sarts) are comparatively poor down to about 26 feet below the surface, at which level the rich deposits begin. In the middle portion of the rivers these latter sands lie below the general water-level of the country, but near the banks they rise higher, and are dry. The Sarts, therefore, prefer to dig their shafts near the river-bank; nevertheless, they work also the sands below the general water-level, leading off the water by subterranean rough-walled channels, a mile or more in length, which are carried approximately horizontally upstream, cutting gradually deeper and deeper into the sand-beds, which dip down stream, then passing through the water base-level, and finally striking bedrock.

The auriferous sands are brought to day by means of sloping shafts communicating with the channels. The shafts, which reach a maximum depth of 47 feet, are not provided with timbering, and they often fall in, with fatal consequences. The 8,000 natives engaged in the work wash annually about 6,450 tons of sand, yielding 5,792 ounces avoirdupois of gold, nearly all of which is exported to Afghanistan. But this industry, though it is many centuries old, has made scarcely any appreciable inroad into the auriferous resources of the country. The researches of Mr. Pokorski during recent years have shown untouched deposits in many rivers (as, for example, in the Safet Darya), not to speak of beds believed to exist deeper still than the two horizons already determined.

The author points out that not only could the gold-washing industry in Eastern Bokhara, if organized on a large scale by Europeans, be made to pay handsomely for many generations to come, but that all the attendant conditions are, on the whole, favourable.

Though there are no forests, trees grow thick in the valleys, and timber (if dear) is to be got in sufficient quantity: it is mainly poplar and walnut. With regard to climate, the rainless season lasts from the beginning of May to the end of November. Even in winter, work can be carried on in the open air, and it is safe to calculate on at least 250 working-days in the year. The water-supply is in some districts sufficient all the year round for all purposes but hydraulicing. South-west of the Khasret-i-Shan, however, and along the tributaries of the Mazur Su, the streams are entirely dried up in the late autumn.

As regards labour, it would be most feasible to employ the hardy though indolent Sarts, on account of their traditional knowledge and extensive experience of gold-washing. The average daily wage of a Sart labourer is 6½d., while that of a Russian labourer is about 1s. 9d. Provisions, such as mutton and rice, are cheap, and scarcity of labour is only probable about harvest-time (August).

The roads are mostly bad. Camel-transport is slow but cheap, and freight by pack-horses costs about half more. It is 10 days' journey to the nearest railway-station, Kokan, on the recently extended Turkestan line.

In the year 1896, Count Vresovski, Governor of Turkestan, promulgated a mining code for the Khanate of Bokhara, wherein it is expressly stipulated that Russian subjects alone shall prospect for gold-deposits or work them when found. Jews, Greeks and Armenians (even if Russian subjects) are excluded.

The author intimates that further details regarding Eastern Bokhara are obtainable from Mr. W. Rickmers-Rickmers, of Bremen, and that Mr. P. A. Pokorski's papers may be consulted in a mining journal published at Kharkov. L. L. B.

MINERAL RESOURCES OF JAPAN.

Note sur l'Industrie Minérale au Japon. *By* PAUL JORDAN. *Annales des Mines*, 1898, *series* 9, *vol. xiv., pages* 530-556, *and map.*

The author travelled through Japan in the autumn of 1897, and, in addition to the results of his own observations, this paper embodies information culled from the reports of the Japanese Department of Mines and other publications.

Coal is practically the most important mineral product of the Island Empire, and the output reached in 1895 the total of 4,772,656 tons. Out of this total 1,376,068 tons were exported to foreign countries, the three largest customers being the British colony of Hong Kong, certain Chinese treaty-ports (Shanghai, Chi Fu, Fu Chau) and British India. It is all of post-Palæozoic (Secondary or Tertiary) age, and 87 per cent. of it comes from two principal areas—one being the Island of Hokkaido, the other comprising north-western Kiushu and the province of Yamagushi.

Turning first to the island of Kiushu, we note that the Nagasaki coal-field is the one that has been longest worked of all Japan: the Nagasaki coal is much esteemed for coke-manufacture, and its composition is as follows:—

	Per Cent.
Water	1·80
Fixed carbon	56·40
Volatile matter	35·50
Ash	6 35
Sulphur	0·72
	100·77

The output from this particular coal-field shows a tendency to diminish.

In the same island, the Fukuoka coal-field occupies from north to south a belt some 60 miles long, which is cut across into two distinct basins by an anticlinal axis. There is railway-communication from the various collieries to the harbour of Takamutsu, where the coal is shipped into junks, and thence transhipped on to larger steamers at Modshi, on the Straits of Shimonoseki.

In the Miike basin, on the eastern shore of the Simbara Gulf, there are two well-recognized seams: the upper or eight-feet seam, which in some places reaches a thickness of 19 feet, and the lower about 6 feet thick. The last-named has so far been worked simply at the outcrop, and then only for local consumption. The beds are extremely regular, and dip southward at 1 in 10. Five shafts and nine borings have been put down: the deepest of these, starting at a point hardly above sea-level, struck the eight-feet seam at a depth of about 780 feet, and it is computed that 50,000,000 tons of coal are in sight, exclusive of what may be got beneath the Simbara Gulf itself. The seams are not fiery, and naked lights are universally used. The mines are very wet, and need constant pumping to keep them dry. A certain proportion of convict labour is employed on the coal-field, in addition to the free labourers. The daily wage of the latter varies from 7½d. to 10d., and the prime cost of a ton of Miike coal is reckoned at about 4s. 10d. Its composition is as follows:—

	Per Cent.
Water	0·63
Fixed carbon	51·10
Volatile matter	39·06
Ash	6·80
Sulphur	3·15
	100·74

In the island of Hokkaido or Yezo, the very numerous coal-seams are interbedded with Cretaceous rocks. Really active working in this field appears only to have begun within the last ten years, although it is true that the Imperial Government started the Poronai mine in 1879, but in 1889 the property was sold to the Hokkaido Coal-mining and Railway Company. The extremes of the seven analyses of coal tabulated by the author from Hokkaido are as follows:—

	Per Cent.		Per Cent.
Water	1·46	to	5·59
Volatile matter	33·90	to	44·36
Fixed carbon	29·99	to	57·60
Sulphur	0·29	to	1·084
Ash	2·38	to	17·24
Specific gravity	1·20	to	1·28

Comparing these Japanese coals with British coal, experiment has shown that to produce the same motive power as that got by burning 15 tons of Cardiff coal it would be necessary to use between 18 and 23 tons of Japanese. Nevertheless, the higher price of Cardiff coal makes the use of the Japanese more economical in the long run. For the supply of men-of-war, Welsh coal still retains its undisputed supremacy in the Far East.

Copper is, next to coal, the most important mineral product of Japan, but the output has somewhat diminished of late years. The most recent statistics available show, for 1893, an annual production of 18,000 tons.

The Ashio mine sends its products about 3 miles by telferage down to the Nikko valley, whence they are taken by horse-tramway to the Nikko railway-station. The cupriferous veins occur at and near the junction of the schists and

rhyolites, which are the chief geological formations of the district. Out of ten known veins only three are actively worked. The ore is a mixture of iron and copper pyrites with a little bornite, and is found in the form of impregnations in the silicified "country." Picking, washing and roasting are carried on at the mine, and the coarse metal undergoes complete refining by an electrolytic process at works in the vicinity of Tokio.

The Besshi mine lies high up in Shikoku, at a distance of about 10 miles from the western seaboard. The ore is partly treated at the nearest shipping-harbour, Niihama, whence a railway runs for 7 miles or so to Tatsukawa, some 2,000 feet below the Besshi escarpment. From the railway terminus, stores, etc., are carried up and copper-ore carried down the cliff by a telfer-cable. From the upper terminus of the cable, a small tram-line runs to the main haulage-road of the mine: this is in a tunnel which cuts right through the mountain. The workings are on a large scale, and, at the time of the author's visit, a shaft 1,770 feet deep had just been completed. The ore is rough-roasted on the spot, and then (as above mentioned) sent down to Niikama for further treatment. The second matte, containing 55 per cent. of metallic copper, is roasted in a reverberatory furnace, yielding a metal containing 99 per cent. of copper, and further refining carries the tenour up to 99·7 per cent.

The author gives statistical tables of exports which show that the British colony of Hong Kong is far and away Japan's best customer for copper, taking four-fifths of the total; while China, Great Britain, British India, and Germany take nearly all the remaining fifth between them.

Antimony occurs in the form of stibine, chiefly in the provinces of Yeshin and Nara, and is largely exported in the raw state. Such metallic antimony as is exported goes mostly to the United States.

Iron.—Japan is poor in ores of this metal. There are some occurrences in the form of veins in the province of Iwate, and fairly abundant magnetite-sands in the provinces of Shimane, Tottori, and Hiroshima. Nearly all the iron and steel used in the Empire is imported from Great Britain, Belgium, and Germany.

Gold.—About 20,287 ozs. were produced in 1895, nearly all in the province of Kagoshima, island of Kiushu. Part of the gold was got from veins, and part was alluvial. At Aikawa, on the island of Sado, there is an important metalliferous mine, which, in addition to gold, yields silver, copper, and lead.

Silver.—The annual output averages 1,833,000 ounces. There are several mines, the most considerable being that of Innai, in the south of the province of Akita. The Hirayu mine, in Gifu, is situated about 6,500 feet above sea-level, on the flank of the Norikura volcano. At Ikuno, in Hiogo, the ore got from the mine near at hand is treated by the Russell process.

Petroleum.—One oil-bearing district is known, near Amase, in the province of Echigo. In 1893, this district produced 2,620,000 gallons of oil: the remainder of the petroleum consumed in Japan is imported from Pennsylvania and the Caucasus.

Sulphur.—An ever-diminishing quantity is got from solfataras, and is almost wholly exported to the United States. L. L. B.

GEOLOGY OF THE NORTH-WESTERN PORTION OF THE GOVERNMENT OF TOMSK, SIBERIA.

Geologicheskoye Opisanie sievero-zapadnoi chetverti 14go lista VIII.-go riada deciativerstnoi topographicheskoi karti Tomskoi Gubernyi. By A. Inostranzev. *Trudi geologicheskoi Chasti Kabineta ego Imperatorskago Velichestva,* 1898, *vol. ii., part* 3, *pages* 1-117, *with a map and two plates.*

In the north and south of the region described in this paper, Middle and Upper Devonian rocks cover a vast area. The former is made up of coralline limestones, interbedded with clay-slates which are generally unfossiliferous; while the Upper Devonian consists of limestones rich in brachiopods, of marlstones, and clay-slates.

Carboniferous strata occur in two areas widely separated one from the other by the Devonian rocks. One occupies the north-eastern angle of the region, the other lies in the extreme south-west. The fossiliferous Carboniferous Limestone forms the lower division of the group, while the upper consists of sandstones and shales interbanded with coal-seams.

The Elbash coal-field extends along the river of the same name in a north-north-easterly direction, forming a belt at least 20 miles in length and not exceeding 1 mile in width. The coal-bearing strata are divisible into four distinct groups: the uppermost, down to 100 feet from the surface, contains three coal-seams. The next includes a seam 5 feet thick: the third comprises one seam no less than 32 feet in thickness, and another about 40 inches thick. Another 5 feet seam is found in the fourth group. So far as these seams have been explored, they show no tendency to thin out.

The Izyla coal-field, 20 miles or so long and 2 miles broad, forms a belt running west-south-west and east-north-east. The seams which have been proved here range from 30 to 70 inches in thickness.

Ever since the Coal-measure period, the region under review appears to have been a land-area, over which atmospheric denudation has had free play. The oldest alluvial deposits occur in the neighbourhood of the streams which run down from the Saláir range. They are mainly reddish loams containing numerous pebbles of very diverse origin.

Gold has been found only in the immediate vicinity of the hills, in a clay very slightly intermixed with sand, and full of rock-fragments ranging in size from small pebbles to large blocks of a hundredweight or more. These fragments are partly quartz (varying in colour from ochreous yellow to snowy white, the latter being the commonest) and partly limestone, dark and light-grey, granular, crystalline, and barren of fossils. This auriferous alluvium was evidently laid down quite near the original outcrops of limestone and quartz.

Eruptive rocks constitute an important feature of the region. They include post-Devonian granites and felsite-porphyries, and contemporaneous Devonian hornblende and plagioclase-porphyrites and tuffs.

Spathose iron-ore occurs, but nowhere in payable quantities. Some of the rocks would make good building-stones. L. L. B.

LIGNITE-DEPOSIT OF MARCEAU, ALGERIA.

Étude géologique et economique du Gisement de Lignite de Marceau, Algérie. *By* E. Dusaugey. *Bulletin de la Société de l'Industrie Minérale*, 1898, *vol. xii., pages* 501-527, *with* 8 *figures in the text.*

Marceau is a village 15 miles (24 kilometres) from the port of Cherchell on the Mediterranean. As early as 1860, traces of mineral fuel were noticed on the side of the hill forming the southern slope of the Marceau valley, and in the bed of the Oued Bouchouaou which descends this valley. The proofs of the existence of a lignite-seam were sufficient for the Government to offer, in 1880, the concession of about 30 acres (12 hectares) to whoever would, under certain conditions, put up glassworks for utilizing the siliceous sand from a neighbouring quarry.

The lignite-seams are comprised in the Sahelian Miocene, which terminates on the west the Algiers Neogene basin, while forming a veritable gulf in the upper and middle Cretaceous series. Two bands of eruptive rocks, stretching from east to west, bound on the north and on the south, the Marceau geological gulf; these eruptions being supposed anterior to the Marceau Sahelian formation deposited at their base.

The exploring works have revealed the existence of three lignite-seams having the following gross and net thicknesses respectively:—No. 1, 13 feet 2 inches (4·01 metres) and 9 feet 2 inches (2·8 metres); No. 2, 7 feet 11 inches (2·43 metres) and 4 feet 11 inches (1·5 metres); and No. 3, 3 feet 7 inches (1·1 metres) and 3 feet 3 inches (1 metre). In the second seam, tree-trunks about 18 feet (from 5 to 6 metres) long, in perfect preservation, and which appear to be conifers, have been found close to the floor.

The lignite is of compact texture and dull black colour, while it breaks up into parallelopipeds; and sometimes, in the middle of the seam, threads of bright black lignite, very compact and of conchoidal fracture are found. The analysis of a sample, carefully taken so as to be representative, showed water 30·8, volatile matter 31·2, fixed carbon 25·4, and ash 12·6 per cent., while the calorific power is 7,672 British thermal units per lb. (4,264 calories per kilogramme). It is considered that 1·5 tons of Marceau lignite is equivalent to 1 ton of Newcastle coal; and the gas-producers at the glass-works are fired with 60 per cent. of lignite and 40 per cent. of British coal.

J. W. P.

GOLD-FIELDS OF THE MURCHISON RANGE, TRANSVAAL.

Le Murchison Range et ses Champs aurifères. *By* A. Bordeaux. *Annales des Mines*, 1898, *series* 9, *vol. xiv., pages* 95-108, *and map.*

These gold-fields are situated in the Zoutpansberg region of the North-eastern Transvaal. From Pretoria, it is a three days' journey by the coach-road through Nylstrom, Marabastad, and Pietersburg to Leydsdorp, the principal town on the Murchison Range and the headquarters of the District Commissioner of Mines. The Murchison Range, itself, is an outlying spur of the Drakensberg, but of much inferior altitude to that great chain. It forms part of the unhealthy "low country," where bush-covered plains are infested with *tsetse* and swamps breed fever.

The basement-rock of the country is hornblendic granite, which sometimes passes into syenite, and sometimes into gneiss. Indeed, the cupriferous gneisses of the Murchison Range are analogous to those of Namaqualand, which are regarded by some geologists as the richest in the world. Overlying the granite

are crystalline schists of Laurentian (?) age, broken through by intrusive diorites, diabases and dolerites in the form of bosses, sills and dykes. It is in the fissures of the fractured granite and schists that most of the metalliferous occurrences are observed. Above these are great outliers of sandstones and shales, of quartzites and conglomerates much disturbed by greenstone-intrusions. The quartzites and conglomerates are seldom mineralized, and even then very poorly.

Turning first of all to the auriferous deposits, these occur in quartz-veins forming lenticular intercalations, sometimes oblique to, but more generally parallel with, the strike of the bedded rocks. The reefs are almost everywhere cut across by diorites and other eruptives. The Silati field, named after that river, comprises three parallel gold-bearing belts. Of these, the northernmost, 12 miles in length, is characterized by the association of antimony-ore (stibine) with the gold. The precious metal occurs in thin flakes in the fissures of the quartz, or in coarse grains; and appears similarly on the surface of the stibine, or mingled with it in an invisibly fine state of division. The "country" consists of metamorphic schists and highly-altered quartzites thrust up on end, and forming a ridge 1,000 feet high. Two miles south of this, the next belt has shown some very rich occurrences at the outcrop, but they do not continue deep down. In the southernmost belt of the three, 12 to 15 miles long, the auriferous deposits have been followed down to a depth of 400 feet. The gold occurs among the flakes of talcose tremolite-schist or in small lenticles and venules of quartz.

Thirty miles north of the Silati is the Klein Letaba gold-field, on the very banks of the Letaba, among the wooded foot-hills (Sutherland Hills) which mark the termination of the "low country." Here granite crops out everywhere, and in it lie long outliers of auriferous metamorphic schists striking west-south-west and east-north-east. The gold-bearing belt stretches over a length of 20 miles, but its extremities alone have been thoroughly prospected. At Letaba, a reef has been proved for a depth of about 150 feet and for an equivalent length; but it appears to thin out on all sides, and in depth ramifies into venules. Sulphides of iron, lead, and copper are associated in this with silver and gold. At Birthday, about ½ mile to the southward, the reef varies in thickness from nothing to 13 feet over a length of 150 feet. It is in the form of a doleritic lenticle, cut across by quartz-veins and diorite-dykes. Here the gold is found more especially along the salbands, in association with iron, copper, lead, and silver sulphides; the gold-tenour diminishes by more than 50 per cent. in depth. Two reefs have been proved at Ellerton, with an outcrop 650 feet long, and going down to 330 feet in depth. The quartz occurs here in parallel bands, and is equally auriferous with the salbands.

The other gold-fields mentioned by the author in the Zoutpansberg region are as follows: (1) The Molototsi, on the river of that name, equidistant from the Letaba on the north and the Selati on the south. Here, in the universally outcropping granite occur auriferous quartz-veins to which, so far, small importance is attached. (2) The Houtboschberg and Hoenertzburg, 10 to 12 miles apart on the Pietersburg road, 32 miles west of Leydsdorp. Here the gold-quartz occurs veining granites, quartzitic sandstones and schists, while immediately to the south crop out the Drakensberg conglomerates. (3) The Marabastad-Smitsdorp, in the neighbourhood of Pietersburg. Here are the same schists, striking south-west and north-east, as on the Silati. Gold-reefs have been proved chiefly on the farms of Roodepoort and Eersteling.

Alluvial gold occurs very seldom in the Murchison Range or elsewhere in the Zoutpansberg; the effect of denudation and erosion has been too great, and the precious metal has been carried far down the Olifants river, away from its

tributaries the Silati and the Letaba. South of Marabastad, however, a few poor alluvial deposits have been found, as also at Tours and Mamotsuri, 20 miles west of Leydsdorp. The annual production of all the foregoing gold-fields ranges between 5,000 and 16,000 ounces, the total produced from 1889 to the end of 1896 being 63,771 ounces, of a value of £242,100. All the indications are against any great development of gold-mining in the Murchison Range.

East of the range are the Palabora hills, 32 miles from Leydsdorp. From the granitic plain rises a ridge of white marble, 2 miles or more in length. Along this runs a magnetite-reef which appears to be the gossan of a cupriferous deposit, speckled as it is with malachite and azurite. From this backbone ramify innumerable thin veins and venules of copper sulphides, bornite, tetrahedrite, etc., excessively rich in copper. The entire ridge is honeycombed with ancient workings, and there is every reason to believe that a great deposit of chalcopyrite occurs at no great distance from the surface.

Cinnabar occurs at the junction of the schists and granite north of Witkopjes, and in grits and quartzites at their contact with porphyrite at Longweberg. A little tin has been found in alluvia on the Great Letaba, and there are some accumulations of rock-salt in natural saltpans in the same neighbourhood.

The author gives a very brief description of some of the Zoutpansberg gold-mines. L. L. B.

LIBOLLITE, A NEW BITUMEN, FROM PORTUGUESE WEST AFRICA.

(1) *O Betume do Libollo;* (2) *Composição da Libollite.* *By* JACINTO PEDRO GOMES. *Communicações da Direcção dos Trabalhos geologicos de Portugal,* 1898, *vol. iii., pages* 244-250 *and* 290-291.

About the end of 1896, a Catholic missionary rediscovered in the Province of Angola a so-called "coal-deposit" covering an extent of 6 leagues along the banks of the Lower Cuanza, whose waters are navigable by steamers between Dondo and Loanda. The outcrop is only a few feet above river-level, and is from 20 to 40 inches thick. A mining concession had been granted many years ago, but had been allowed to lapse.

Hand-specimens having been deposited at the Ministry of Marine in Lisbon, the author made a careful examination of them, the result showing that the mineral is certainly not coal, but has close affinities to albertite.

It is of a pitch black, with resinous lustre, shows uneven fracture, sometimes conchoidal, and yields a dark brown streak. Its hardness is 2·5 in the Mohs scale, and its specific gravity is 1·1. It burns brightly with a good deal of smoke on the application of a candle or gas-flame, giving forth a very disagreeable bituminous odour. It intumesces in a most extraordinary way, swelling up to a volume four or five times that of the original, and yielding a dull, fragile, "blistery" coke, of low specific gravity, difficult to reduce to ashes.

The results yielded by chemical analysis are as follows :—

	Including Ash.	Excluding Ash.
Hydrogen	7·83 ...	8·412
Oxygen	8·80 ...	9·415*
Nitrogen	1·71 ...	1·837
Carbon	74·74 ...	80·300
Residue	6·92	

* 1·97 in albertite.

For comparison, the author tabulates analyses of albertite, Virginia grahamite, Dead Sea asphalt, and Hanoverian petroleum.

Albertite yields a black streak, and, when ground to powder, remains black. These properties differentiate it from the mineral now described, as well as the carbon and nitrogen percentages (86·04 and 2·93 respectively in albertite); and the author proposes for the new mineral the name "libollite," Libollo being the locality where it occurs. Its calorific power is equivalent to 4,833 calories. Libollite shows no traces of plant-structure; and the author is inclined to believe that the occurrence will be found, like that of albertite, to consist of fissure-deposits starting from a great depth. L. L. B.

LIGNITES OF TIERRA DEL FUEGO, ARGENTINE REPUBLIC.

Análisis química del Carbon de Tierra del Fuego. By JOHN J. J. KYLE. *Anales de la Sociedad Científica Argentina*, 1898, *vol. xlvi.*, *pages* 236-237.

The author examined samples of two varieties of lignite brought from Slogget Bay. No. 1 is a lignite of first-rate quality, of a jet-black hue, with conchoidal fracture and black streak. It burns with a short, rather dull flame; its specific gravity is 1·273. No. 2 has but little lustre, and is of a reddish hue, with a coffee-brown streak. It burns more readily and with a longer flame than No. 1, but is of a far inferior quality. The results of chemical analysis are as follows:—

Samples.	I. Per Cent.	II. Per Cent.
Hygroscopic water at 110° Cent. ...	26·85	... 17·00
Volatile constituents	31·63	... 31·88
Fixed carbon	39·47	... 18·40
Ash	2·05	... 32·72
Sulphur	0·466	... Not ascertained
Absolute calorific power, measured in calories	3,482	... 2,324
Coke	Hardly caked together	Pulverulent
Colour of ash	Red	... Grey

It has not yet been shown whether these lignite-deposits are favourably situated for working on a large scale. L. L. B.

GOLD-BEARING BEDDED-VEINS OF PASSAGEM, BRAZIL.

Der goldführende, kiesige Quarzlagergang von Passagem in Minas Geraes, Brasilien. By E. HUSSAK. *Zeitschrift für praktische Geologie*, 1898, *pages* 345-357, *with 9 figures in the text.*

The Passagem gold-mine is situated about 4½ miles east of Ouro Preto, the capital of the state of Minas Geraes. In mineral wealth it is reckoned among the richest in Brazil, ranking next to Morro Velho; and, although it has been worked more or less ever since the beginning of this century, its true development only began after it had passed into the hands of a reconstituted British company. From 1884 to 1893, out of 287,626 metric tons of vein-stuff, 76,360 ounces (2,375 kilogrammes), or not very far short of 0·1 per cent., of gold was got. Besides this, a quantity of metallic bismuth averaging 80 pounds per annum is separated from the gold. In 1892, the workings reached the depth of 1,462 feet.

The metalliferous vein is chiefly made up of milk-white quartz, tourmaline, and mispickel, with iron pyrites and magnetic pyrites as subordinate associates. It

belongs to the category of bedded veins, being interstratified with flaggy quartzites, etc. It strikes north-east and south-west, and dips 18 to 20 degrees south-eastward. The rock-succession is as follows:—Quartz-mica-schists at the base, then greenish-white flaggy quartzites, above which comes the vein. There is a salband, about 39 inches thick, at the footwall, consisting of black graphitic schist, while the salband at the hanging-wall is rarely graphitic, but is made up of garnet, pyrites, and black mica. Above the upper salband is a thin stratum of cryptocrystalline schists, consisting of quartz and black mica. Overlying this are the itabirites, a distinctly bedded mass no less than 160 feet thick, of granular quartz and shining flakes of iron-glance. The itabirites are overlain by a crust of *canga*, a brown porous conglomerate: this is made up of fragments of the underlying rock, bound together by a ferruginous, argillaceous cement.

The auriferous vein itself really forms a series of lenticles, here swelling out to 50 feet, and there contracting to 6½ feet. Where thickest, it is generally poorest, and also the more quartz that goes to its composition, the poorer it is. In the richer portions, native gold is discernible with the unaided eye, in grains or crystals, encrusting mispickel and tourmaline. No gold is found in the flaggy quartzites, but in the itabirites nearest the vein, gold has been proved in the proportion of 1·8 per million.

The following is a complete list of the minerals found in this mine—(1) *Vein-minerals:* Quartz, mispickel (the most abundant of the sulphides present), iron pyrites, copper pyrites, magnetic pyrites, galena, stibnite, gold, calcite, dolomite, siderite, and limonite—the last five being evidently secondary infiltration-products. (2) *Granite-minerals:* Quartz again, muscovite, also a green chromic muscovite (fuchsite), biotite, oligoclase-albite, zircon, monazite, xenotime, amphibole (?), magnetite, and rutile. (3) *Contact-minerals:* Tourmaline, andalusite, staurolite, disthene, garnet, hercynite, cummingtonite, and biotite again. Of all these occurrences the author gives a detailed description, but it will be sufficient here to summarize his remarks on the gold. As before hinted, this is most frequently present in the crystalline masses of mispickel and tourmaline. It is also finely disseminated in aggregates of tourmaline microcrystals, and occurs in well-formed octahedra on the walls of druses of mispickel; but, as a rule, the precious metal is scattered very irregularly in minute particles, or in thin flakes and jagged fragments. There is also a secondary formation of native gold on the basal cleavage-surfaces of tiny tourmaline-prisms.

The bismuth, of which mention has already been made, probably occurs as a natural alloy with the gold, for it has been impossible so far to trace a single bismuth-mineral at Passagem. It should be noted, however, that in other localities not far off, bismuth-minerals have been found in association with gold. The silver-content of the Passagem gold is infinitesimal.

A petrographical description is given of the mineral-associations in the quartz-vein, in the schists in immediate contact with it on either wall, and in the itabirites, mica-schists, flaggy quartzites, etc., and the author tabulates the following conclusions as the outcome of his careful mineralogical and petrographical examination of the rocks:—

1. The Passagem quartz-vein is of intrusive origin, and is, in fact, a hyperacidic granite apophysis.

2. It broke through the quartz-schists (itacolumite-slaty quartzites according to Dr. Ferrand), crushing them up and in part absorbing them, and formed a distinct contact-zone both at the hanging-wall and at the footwall.

3. It is, therefore, of later age than any of the country-rocks, all of which are metamorphosed sedimentaries. L. L. B.

GOLD-PLACERS OF THE DEBATABLE LAND, NORTHERN BRAZIL.

Les Placers aurifères du Contesté Franco-brésilien. By E. D. LEVAT. *Revue Scientifique*, 1898, *series* 4, *vol. x., pages* 7-15.

The territory in question is claimed by France to belong to French Guiana, in virtue of the treaty of Utrecht; whereas Brazil claims that, in the aforesaid delectable treaty, the river Yapoc was confounded with the river Oyapok, and that the boundary should be shifted by 125 miles. The rival claims have now been submitted to the arbitration of the President of the Swiss Confederation; but our author proposes that his countrymen should meanwhile manufacture vested rights ("secure effective occupation" the wise it call) in the most valuable portion of the Debatable Land, by multiplying expeditions into the interior, by establishing direct steamboat communication with Cayenne, and by setting up favourable Customs tariffs.

The river Araguari cuts the territory in dispute into two physiographically distinct portions:—South of it stretch boundless savannahs, where the Indian half-breed pastures great herds of cattle; north of it lies a region of mountain and valley, through which flow the Carseveno, the Cunani, the Oyapok, etc., their banks dotted with gold-placers. In 1893, two prospectors went up country from Cayenne, and, after a sojourn of 2 months on the banks of the Carseveno, returned with a load of 795 lbs. of gold. The usual rush followed, and many blacks from the British West Indies (Barbados, Santa Lucia, etc.) took part in it, with the result that the floating population of the Debatable Land reached at one moment 10,000 souls, despite the difficulties and dangers inseparable from the journey thither. Numbers perished by the way, and many died of privation when they had reached the goal.

The area upon which the rush converged is a remarkably small one; it extends hardly more than 3 miles up the Lorenz or Factory creek and the same distance up the Great creek. In the former, at the point where a small stream known as the Onemark debouches into the valley, the richest accumulation of native gold was struck, and here the miners' sluices lay literally cheek by jowl. At this favoured spot, the deposit seemed to grow richer the deeper down it was worked: indeed, throughout the Carseveno basin the top barren layer is so thin that spangles of gold were brushed in appreciable quantity off the roots of the plants. But the workings have been mostly stopped in consequence of the insufficient outflow from the sluices. In a district without mining legislation, it has been found impracticable to undertake such works as would secure a proper outfall, or to prevent robbery of water from the down-stream miners by surreptitious up-river intakes. All that is being done now is to wash the old tailings for gold, but even this is extremely profitable, and the author believes that if a great waste-flume were made it would still pay very well to re-wash these washed tailings.

Another circumstance which has contributed to the decay of mining-industry hereabouts is the behaviour of the workpeople. No reliance could be placed on them. Not only did they steal nuggets, but they worked their employers' ground (after working-hours and on Sundays) for their own profit; and, as if by accident, it always happened that the richest portion of the placer would be left for this "overtime." On the other hand, no case of robbery with violence has been authenticated, either on the placers or on the trails down to the coast.

Meanwhile, those enterprising persons who are clamorous for concessions, to make assurance doubly sure, have registered both with the French and Brazilian governments claims covering 125 to 250,000 acres apiece, and this will complicate considerably the task of arbitration.

The author admits that the rapids which obstruct so many of the rivers will constitute an insurmountable obstacle to any great development of steam-navigation, and he therefore sketches out a plan of railway-construction by convict-labour. The distance from Cayenne to the gold-fields of French Guiana proper is barely 100 miles, and the proposed line would have a total length of 220 miles.

No separate statistics of gold-production as regards the Debatable Land are given by the author, but he estimates the actual (not the declared) value of the total annual export of gold from Cayenne at £500,000. This includes the gold from the disputed territory. L. L. B.

GOLD-PLACERS IN FRENCH GUIANA.

Les Placers aurifères de la Guyane Française. By E. D. LEVAT. *Revue Scientifique*, 1898, *series* 4, *vol. ix.*, *pages* 705-712, 745-749.

French Guiana possesses the richest gold-placers known in South America, yet it contrasts unfavourably, in respect of general prosperity and economic development, with the British and Dutch Guianas. The colony, rich at one time by its trade in spices and dyes, had been brought to the verge of ruin by the sudden abolition of slavery, when in 1853 certain Brazilians (who were fleeing from military service in their own country) discovered some gold-bearing alluvia on the banks of tributary creeks of the Appruaga river. A year or two later, these were worked with extraordinary success by a company which had obtained mining rights over an area of 500,000 acres. Then gold was sought and found in other districts, in the river-basins of the Sinnamary, the Mana, and the Maroni. The discovery of the St. Elias placer in 1878 was followed in 1889 by the rich finds on the Awa.

All the placers known and worked are in the immediate neighbourhood of streams which are navigable either by steam-launches or by native pinnaces. Remoter deposits are unknown or untouched, precisely because there is no means of access to them under present conditions. The prospectors start on their journeys of exploration, as a rule, at that period of the dry season when the water-level in the rivers is such as to make the passage of the countless rapids which obstruct their course somewhat less arduous: for this purpose the waters must be neither very low nor very high. The rivers forming the only routes into the interior of the colony, a reduction in the number of portages becomes a primary consideration. Freights are heavy: thus, from St. Laurent or Albina up the Maroni 50 miles to the Beiman Creek placer, with two rapids to pass, the charge is £6 per ton. Goods going up from the above-mentioned ports to the Awa placers, a distance of 150 miles with 15 rapids to pass, pay £16 per ton. Negroes on their way to work at the placers pay 18s. to 50s. for their passage up river, and about a third of the price to come down river. The gold sent down to the coast from the placers is packed in boxes hooped with iron, to which (in view of possible capsizings) a long line with a small but strong float painted red is attached.

The difficulties of prospecting in the country are intensified by the dense cloak of vegetation with which it is covered. The author never saw one bare hill-top, and however high may be the ridges that one climbs no vast expanse of country ever meets the eye.

A table of the curious local standards of gold-tenour is given: these range from the infinitesimal proportion of $5\frac{1}{2}$ to 2,000 grains ($\frac{8}{100}$ gramme to 166·5 grammes) of gold per cubic metre of alluvium. In French Guiana, prospectors estimate the value

of a placer by sampling a few inches in thickness of the uppermost portion of the bed-rock, and of the lowermost alluvium in immediate contact with it: their assays represent, therefore, the "cream" of the placer.

The placers are generally in marshy ground, overgrown with cabbage-palm (*Euterpe edulis*) which is easily cut. The negroes are very expert at clearing off this vegetation, aided by the circumstance that the roots of trees in Guiana have a tendency to spread parallel to the surface instead of striking vertically downwards. Some placers can be reached by steam-launches; beyond this, the means of transport are what they were in 1853; loads are carried upon men's backs along the roughest imaginable native paths, toiling up steep hills and splashing through swamps. The bridges are just tree-trunks thrown across the streams, and the wayside habitations are mere straw huts. Beasts of burden or draught-animals are not to be found, and, as a preliminary condition of their existence in the country, much forest must needs be cleared and turned into pasture. Such are the drawbacks which prevent the shallow placers of French Guiana from being worked on the same economical system as the very similar shallow placers of Siberia. Moreover, there is not sufficient slope in the placers nor sufficient room for tailings; wherefore the American fixed sluice is inapplicable, and hydraulicing is equally out of the question.

They are worked by means of a portable sluice, supplied with water from an intake farther up stream. The sluice is put down on the site of the workings, and is shifted up stream concurrently with the working-face. It is made up of a series of wooden troughs which are slightly narrowed at one end so as to dovetail into each other: the usual length of these is 13 feet, their mean breadth 1 foot, and their vertical sides are about 1 foot in height. They are carried by piles fixed in the bedrock. From 12 to 15 persons are employed at each working-place; about 5 lbs. of mercury is thrown into the sluice at the start, and cast-iron riffles placed at the ends of the troughs retain the mercury and amalgam.

A large number of placers are lying idle, in consequence of the heavy cost of working them by the methods at present pursued in the colony: below a tenour of about 3 grains per cubic foot of alluvium, it does not pay to work the deposits. The author suggests the introduction of dredges, after the pattern of those used in New Zealand, and, more recently, in the United States. This would be the easier that in French Guiana the bedrock is almost invariably mere clay. The Mana, Sinnamary, and Appruaga rivers are all unmistakably auriferous: a little digging with a long-handled spade brings up payable alluvium from their beds, and a vast amount of material that does not pay to work now would pay very well on the dredging system.

As regards labour, the author points out that in the British and Dutch Guianas the negroes contract to work on the placers at a fixed daily wage, and receive in addition their board, medical attendance, and a free passage The contracts hold good for 6 months, and the colonial authorities see to it that both parties to the contract carry out fairly its stipulations. But in French Guiana it is far otherwise: the great majority of the colonists are negroes in full possession of the same civil and political rights as the white man. This majority elects the Colonial Council, and to negro influence may be traced the culpable slackness of the authorities with regard to the administration of the labour laws. Many a miner gets an advance on his wages, which he spends, and then decamps to another mine, where he enters into a fresh contract, which he evades in the same manner. The employer's only remedy is the cumbrous mockery of a suit in the civil courts against a penniless defaulter.

The immigration of Indian coolies has been prohibited for the past 10 years in French Guiana, while they pour into the neighbouring British and Dutch Guianas, where they work on the plantations and mines. To convict-labour, or to that of discharged, time-expired convicts, the author expresses himself opposed.

For further information the reader may consult the same writer's voluminous manual: *Rapport à M. le Ministre de l'Instruction Publique sur l'Exploitation de l'Or en Guyane—Guide pratique pour la Recherche et l'Exploitation de l'Or en Guyane française.** L. L. B.

ORE-DEPOSITS IN THE ATACAMA DESERT, CHILE.

Ueber einige Erzlagerstätten der Atacamawüste. By OTTO NORDENSKJÖLD. *Bulletin of the Geological Institution of the University of Upsala*, 1896-97, *vol.* iii., *pages* 343-351, *with* 4 *figures in the text.*

This paper constitutes the first instalment of an account which the author proposes to give of his journeys in August and September, 1896, to about a dozen mines in the provinces of Coquimbo and Atacama.

Our attention is first of all directed to the copper-mine of Amolanas, in Atacama, latitude 28° south. North-east of this mine is a great series of red, poorly fossiliferous sandstones of Liassic age; south-west of it are huge masses of augite-porphyrite, while between the two is an intrusion of quartz-porphyry some 325 feet thick. At the contact between this porphyry and the sandstones copper-glance is disseminated over a breadth of 100 feet in little rounded nodules of the size of a walnut. The ore is nowhere seen to occur in the form of veins or infillings of cracks and fissures.

The author points out that in the case of most of the occurrences of copper-glance this ore gives place in depth to copper-pyrites, but the workings at Amolanas have not been carried much beyond 300 feet down, and thus far no such passage has been traced there. The only other copper-ore observed was malachite, which impregnates the rock in the uppermost portions.

Very sharply are the inclusions of copper-glance marked off from the enveloping porphyry, and, as a rule, no ore occurs in the groundmass of the rock. The porphyry is seamed by veins of diabase, and the sandstones near the junction are cut by a small dyke of melaphyre. The author considers that the ore must have been brought in in the molten condition by the porphyry itself.

The annual production is 20,000 tons, containing 5 per cent. of metallic copper —a percentage which may be increased by a simple process of washing to 25. Want of water-power and the great distance from any railway-station are the sole obstacles to a vast development of the mining-industry here.

The next locality to come under notice is Los Bordos, also in Atacama, latitude 27° 40′ south. Here the Elisa mine, one of the most considerable in Chile, produces annually 12,000 or 13,000 tons of ore, with a yield of 0·1 per cent. of refined silver. The argentiferous deposit averages in thickness from 3½ to 7 feet, strikes north 30 degrees east, and dips 15 to 30 degrees south eastward; the ore is mainly native silver and horn-silver. These are accompanied by mercury in various combinations, but sulphur, arsenic, and antimony compounds are conspicuous by their absence.

The longest working follows the dip to a depth of about 1,620 feet, and here the hanging-wall is seen everywhere to consist of a light sandy tuff, called by the

* *Annales des Mines*, 1898, series 9, vol. xiii., pages 386-439, 443-564, 569-616, and plates V. to X. (maps, sections, etc.).

miners *cantera* (100 to 150 feet thick), while the footwall is frequently amygdaloidal augite-porphyrite (*manto negro*), at most 7 feet thick. The vein-stuff itself, or *manto bordon*, is a perfectly soft, greasy rock, extremely like talc-schist, never more than 10 feet thick. As the strike changes, the hanging-wall is found to pass into a decomposition-product, and there is *pari passu* an impoverishment of the vein-stuff. In the easternmost part of the mine, an augite-porphyrite breccia or agglomerate, very poor in silver, was being worked at the time of the author's visit.

The ore undoubtedly originated in the massive augite-porphyrites which follow upon the *manto negro*, and though it is not found in paying quantities in the former rock, its presence has been proved therein over and over again, and there it is much associated with mercury compounds. The workable silver-ore is evidently concentrated along a line of crush, at the junction between the above-mentioned *cantera* (tuff) and the augite-porphyrite.

The author concludes with a brief petrographical description of the rocks, and the illustrative sections in the text enable the reader to picture exactly their relative positions. L. L. B.

CARACOLES MINING DISTRICT, CHILE.

Estudio sobre el Mineral de Caracoles. By F. Labastie. *Boletin de la Sociedad Nacional de Mineria*, 1898, *series* 3, *vol. x., pages* 157-174.

An American-Indian legend had, during many generations, pointed to the existence of rich silver-mountains in the unexplored wilderness of Atacama; but it was not until the spring of 1870 that the accuracy of oral tradition was proved by the discovery of the legendary Silver Range in the argentiferous deposits of Caracoles. The discoverers were four prospectors who had started from Mejillones, on the Pacific coast, and the masses of horn-silver which they brought back with them were impressive tokens of the mineral wealth of these mountains.

Caracoles (latitude 23° 3′ south, and longitude 69° 13′ west of Greenwich) is situated in the midst of the Atacama desert, at a point equidistant from the shores of the Pacific and from the chain of the Andes, south-east of the Limon Verde range, and 126 miles north-east of Antofagasta harbour. A railway connects this port with Sierra Gorda, whence a fairly good cart-road runs for 26 miles to the Casa de Tabla mines, which lie at the foot of the Caracoles range. Thence, although the ascent is steep, vehicular traffic is easily carried on up to the highest mines in the field, and the extension of the railway would not be a very difficult matter. All this district is now Chilian territory, ceded by Bolivia after the war of 1879.

It is at the extreme north of the range, above which towers the great cone of the Sentinel, on its eastern and western flanks, that the three great belts of ore-deposits with their groups of argentiferous veins occur, the whole forming the Caracoles mining-field. Despite the rainless climate, water is easily procurable: to begin with, brackish springs well out at the base of the Limon Verde, and were used by the early miners for drinking purposes and for the apparatus set up in the first established works for treating the ore. Later on, fresh water was found 10 miles west of Caracoles at Victoria Peak; and 10 miles north, potable water of still better quality was struck, which nowadays constitutes the chief supply of the district. The abundant brackish waters from the deeper mines are used for watering the horses and mules, and for the chemical treatment of low-grade ores.

An interesting meteorological observation is noted by the author, after a residence of more than 20 years in the district:—Although rain is as infrequent as ever, the dryness is now less extreme, the water brought to the surface in over fifty mines having induced a certain amount of saturation of the atmosphere over that portion of the great desert of Atacama.

The rush of immigrants took place from 1871 to 1877, when the mining population of the Caracoles district reached 18,000 souls. In those years, no fewer than 4,000 claims were registered. Towns rapidly sprang up, with all the usual appurtenances of civilized life, as it is understood in Spanish America. Then the customary reaction set in. The crowd of unlucky speculators, sharpers, wastrels, and ne'er-do-weels abandoned the district, to its great advantage, and the quiet development of the genuine mines pursued the even tenour of its way, despite injudicious legislation or meddlesome officialism. The present situation, however, is depicted in gloomy colours by the author: political crises, the rise in exchange, the fall in the value of silver, the extravagant freights, and the high prices of articles of prime necessity are freezing the marrow of enterprise and driving out the ever-diminishing population, which at the end of 1895 numbered barely 1,000.

Of the 4,000 claims registered in the years of the boom, 260 alone survive: the area of each of these varies between 2½ and 12½ acres, and all of them are under embargo for the payment of the "mining patent." The author supplies a complete alphabetical list of the surviving mines, with their areas and the names of the owners. From 1870 to the end of 1894, Caracoles produced 47,983,020 ounces of fine silver, or an average of 2,000,000 ounces per annum, with an average population of 10,000. During the last 3 years, with an average population of 1,000 only, the annual production of metallic silver has ranged from 460,000 to 530,000 ounces. It is not want of ore but want of labour which is keeping the production down, and at least 100 more miners could be fully employed.

The author enters into no details regarding the mineralogy or geology of the deposits.

L. L. B.

LIGNITE FROM MAGALLANES, SOUTHERN CHILE.

Ensaye de una Muestra de Carbon de Magallanes. By MARCO CHIAPPONI. *Boletin de la Sociedad Nacional de Mineria*, 1898, *series* 3, *vol. x.*, *pages* 304-310.

In view of the importance of the discovery of beds of workable lignite in the provinces which border on the Straits of Magellan, in Tierra del Fuego on one side, and in Magallanes on the other, the author has made a very elaborate study of a specimen of the mineral from the last-named district.

It was taken from near the surface of the outcrop, and is a compact mass with flaky cleavage, conchoidal fracture, of an opaque black, giving a dark-grey streak, and alternately lustrous and dull in bands. It does not soil the fingers, and its number in the scale of hardness is 3. In dry air it cracks, much in the fashion of damp clay when exposed to the sun. It burns with a very bituminous flame, without giving off even a trace of sulphurous gases, and leaves an extremely light residue, without making any clinkers. Its specific gravity is 1·351, exactly that of the Hesse Cassel lignite.

By fractionated distillation, the author obtained 48 per cent. of coke of a lustrous aspect, pulverulent. This, when burnt in atmospheric air, leaves 24 per cent. of ash (or 11·5 per cent. of the total lignite). The ash is of a red colour, and infusible at 1,652° Fahr. (900° Cent.). Its composition is as follows:—

	Per Cent.
Silicate of alumina	58
Calcium carbonate	12
Magnesium carbonate	3
Iron oxide	15
Silica	12

The results of the analysis of the lignite, as a whole, are expressed as follows :—

	Per Cent.
Hygroscopic water	10·0
Combined water	20·0
Benzenes	2·5
Hydrocarbons and oxygen	25·5
Carbon	36·5
Silicate of alumina	6·77
Calcium carbonate	1·48
Magnesium carbonate	0·43
Iron oxide...	1·81
Silica	1·10

The calorific power is 3,500.

It is evident that this lignite has been much deteriorated by atmospheric agencies. Nevertheless, its properties place it beside lignites already much used in industry, and experiments made with it in furnaces show that, in regard to quality, if best Lota coal be taken as 100, the Magallanes lignite is 67.

The author states that his studies of coal-deposits in Great Britain, Italy, Austria, and Peru have led him to an opinion entirely at variance with that of many mining experts, who hold that coal got at the outcrop is identical with coal got at some depth from the surface. He considers that atmospheric agencies may profoundly modify the properties of coal at depths as great as 150 or 160 feet below bank. Therefore the fact that, in 1872, Mr. Lorenzo S. Rodriguez published an analysis of Magallanes lignite, yielding far more favourable results than those recorded by the present author, is easily explicable when one bears in mind that the samples analyzed by Mr. Rodriguez were got at a vertical depth of 70 or 80 feet below the surface, at a distance of 572 feet from the opening of the adit.

It is thus shown that, in depth, the proportion of volatile constituents in the lignite increases, while that of ash diminishes, the correlative result being enhanced calorific power.

The author thinks that the Magallanes deposits could be utilized for coaling steamers, provided their boilers were so modified as to admit of the use of high-class lignites, and thus the Chilians would become independent of British coal.

L. L. B.

IRON-ORE AND LIGNITE IN HAYTI, WEST INDIES.

Geologische Studien in Haïti: I. Aus der südwestlichen Halbinsel. By L. Gentil Tippenhauer. *Petermanns Mitteilungen,* 1899, *vol. xlv., pages* 26-29, *and plate III.*

In south-western Hayti, the author found hydrated oxides of iron in the post-Pliocene basalts of Grande Savane and Morne Carré, outcropping with surprising regularity along a west-north-west and east-south-easterly strike. It had before been observed by local field-surveyors that the compass-needle was constantly deflected in the basaltic areas of Anse à Veau, Aquin, and St. Louis, and this

deflection was considered to be due to the presence of iron-ores, even where outcrops of such have not yet been traced. But the minute crystals of magnetite described by the author as present in these particular basaltic areas are of themselves quite sufficient to deflect the needle. The magnetite, it is true, forms in some places so considerable a percentage of the spheroidal basalt that it gave rise to the most extravagant delusions regarding a possible development of an iron-mining industry on a large scale. Such as it is, however, the magnetiferous basalt of south-western Hayti would not repay working.

In the Morne à Bekly and Terre Neuve districts in the north of the island occur, however, iron-ores in compact veins containing 62 per cent. of metallic iron.

Returning to the subject of the hydrated oxides of the south-west, the author points out that these, in contradistinction to the magnetites, are of industrial importance. The most considerable mine so far worked is situated in the Tomau ravine near the road from Chapelle Morenceau to the Serpent river-valley. Here a vein 16 feet thick yields an ore of the following composition:—

	Per Cent.
Water	14·95
Iron sesquioxide (metallic iron, 15·37)	21·95
Silica	35·50
Sulphur	0·13
Phosphorus pentoxide	0·31
Alumina	21·30
Titanic oxide	3·73
Magnesia	0·51
Lime	0·43
Copper	trace
	98·81

From the metallurgical point of view, this is hardly satisfactory, but the ore makes a splendid colouring-material (deep brown to brilliant red), and is favourably reported on by the management of a German colour-factory.

In the period contemporaneous with the basaltic outpourings, the Asil Valley was a vast freshwater lake. Bands of lignite are interspersed with the marls which were quietly laid down at the bottom of this lake, and their most notable outcrop is on the Bedêne plantation, 11½ miles from Aquin. Here, at about 600 feet above sea-level, the lignites and intercalated marls show a combined thickness of 172 feet—out of this one may reckon a thickness of 17 feet of pure lignite in three bands. An analysis made in Paris showed:—

	Per Cent.
Water	26·86
Volatile matter (other than water)	32·56
Carbon	23·23
Ash	15·35
	98·00

Calorific power: undried, 3,177 calories; dried, 4,645 calories. This lignite does not form coke, and it is questionable whether the deposit would repay working.

Mention is made of old traditions regarding the occurrence of mercury among the basaltic rocks, but after careful investigation the author has failed to find any evidence that can be held to substantiate these traditions. L. L. B.

CUPRIFEROUS DEPOSITS OF INGUARAN, MICHOACAN, MEXICO.

Sur le Gîte cuprifère d'Inguaran, Etat de Michoacan, Mexique. By E. CUMENGE. *Bulletin de la Société française de Minéralogie*, 1898, *vol. xxi.*, *pages* 137-142.

The mountain of Inguaran forms one of the spurs of the Sierra Madre, in that portion of it which runs through the state of Michoacan in north-western Mexico. From the federal capital 18 hours' journey by rail bring the traveller to Pazcuaro junction, whence a branch line runs to Morelia, the chief city of Michoacan. From Pazcuaro to Inguaran, however, the only means of transport at present is by pack-mules, a three days' ride along very rough bridlepaths.

The recent volcanic cone of Jurullo (1,950 feet), dating only from the last century, rises from the plain within a mile or two of Inguaran. At the last-named locality, the evidence of incomparably more ancient volcanic eruptions exists in the shape of an enormous flow of andesite, and the great deposit of copper pyrites lies between this and the granite which forms the backbone of the neighbouring mountain-ranges. The cupriferous masses, locally termed *guedales*, occur in a belt of microgranulite, some 2,250 or 2,550 feet wide and 5 or 6 miles long which intervenes between the andesite and granite from base to summit of the mountain (3,250 feet difference of level). So rich are these brecciiform masses of altered microgranulite, wherein the chalcopyrite or copper pyrites forms the cementing-material, that one single mass at the base of Inguaran contains, according to the most moderate estimates, 30,000,000 tons of ore.

Relics of ancient workings show that the Aztecs, and after them their Spanish conquerors, extracted the ore for the manufacture of domestic utensils. Indeed there are still some primitive smelting-works in the little town of Santa Clara del Cobre, where the pyrites, crushed by hand between two stones, is washed, roasted, and finally smelted in a hole dug in the ground, by means of charcoal fuel and hand-bellows. The black copper thus obtained is refined on a small hearth, and the metal (which is of first-rate quality) is hammered into shape by very skilful workmen.

The chalcopyrite is associated at Inguaran with bornite and black sulphide or chalcosine, both minerals much richer in copper than pyrites. These two minerals are sometimes found here in rather thick layers, encrusting the less altered blocks of microgranulite in the breccia. Some of these harder blocks are several feet thick, and form barren *caballos* (horses) in the midst of the ore-deposit. The percentage of metallic copper in the ore ranges from 3 to 4, and the concentrates obtained by the primitive treatment described above usually contain 32 to 33 per cent. of the metal. The author believes that this high percentage is due to the almost entire absence of iron pyrites, an absence very unusual in cupriferous deposits.

The mineral resources of Inguaran would allow of an annual production of 25,000 to 30,000 tons of metallic copper, and it is expected that working will be started on a large scale with modern methods, so soon as readier means of access to the locality have been provided. L. L. B.

SILVER-ORES OF PACHUCA, MEXICO.

Les Filons argentifères de Pachuca, Mexique. By EZEQUIEL ORDOÑEZ. *Bulletin de la Société géologique de France*, 1898, *series* 3, *vol.* xxvi., *pages* 244-258.

The district of Pachuca is situated on the south-western slope of the sierra of the same name, which forms the north-eastern wall of the great basin of Mexico city. The sierra runs north-west and south-east for about 26 miles, and its highest summit, the Navajas, reaches the altitude of 10,440 feet above sea-level. The

town of Pachuca lies about midway along the range, occupying both sides of a ravine walled in by lofty mountains. Through these latter course the metalliferous veins, over an area of about 5,000 acres.

The entire sierra is built up of Tertiary eruptive rocks, the oldest being andesites, the next in time rhyolites, and the youngest basalts. The andesites, which form the country-rock of the veins, are extremely variable in colour and structure, and in many localities are covered by sheets of spherulitic or petro-siliceous rhyolites. The author considers that all these rocks are the products of successive fissure-eruptions. The later andesites are more siliceous than the earlier, giving a premonition, as it were, of the next following outburst of petro-siliceous rocks. The last-named crashed suddenly through the andesitic crust, and, as the bigger fissures reopened to yield them passage, narrower parallel cracks were formed through which the accessory eruptive phenomena found a vent in the shape of fumaroles and thermal siliceous waters. These waters brought with them sulphides, chlorides, and other metallic salts from great depths, and deposited them as encrustations on the walls of the fissures. Then followed a long period of repose, interrupted by the outpouring of basic lavas along the lines of least resistance. It is supposed that the andesites of the Sierra de Pachuca made their appearance in Miocene times, and that their eruption was the result of the movements which folded the great series of Cretaceous rocks in the immediate vicinity of the range. The slopes facing the great basin of Mexico are thickly mantled by the lacustrine Pliocene and post-Pliocene deposits, which form the bottom of that vast expanse.

The metalliferous deposits are all comprised within four or five groups of parallel fissures striking nearly due east and west. A few secondary fissures branch off from the main system, but never at an angle exceeding 30 degrees. Quartz is the predominating constituent of the vein-stuff. In thickness, the deposits rarely exceed 23 feet: the Vizcaina vein, which, here and there, reaches the maximum, runs for 10 miles from the Leones ravine on the east into the district of Real del Monte, cutting through the Sierra de Pachuca on its way. The outcrop of the Cristo vein (3 to 16 feet thick), may be traced for about 2½ miles, and its further extension is masked by the labradorite-rocks of the summit of mount San Cristobal. Similarly the outcrop of the Analco vein (4 to 20 feet thick), may be followed for close upon 4 miles, while its prolongation beyond the valley of San Bartolo is hidden by beds of volcanic tuff. The Valenciana vein ranges in thickness from 27 to 66 inches.

Sometimes the outcrops of the veins, *crestones* as they are called by the Mexican miners, form prominences jutting 1 or 2 feet above the surface of the ground, the whiteness of the quartz gleaming from afar against the dusky yellow-brown of the soil. Thus, from the city of Pachuca itself, may be discerned the *creston* that runs down from the summit of Santa Apolonia. But the veins which are richest in depth, such as the Vizcaina already mentioned, do not give rise to protuberant *crestones*: the quartz occurs in thin bands, much interseamed with clay and venules of calcite. Some portions of the quartzose *crestones* are associated with altered pyrites, pyrolusite and argentiferous minerals, containing a percentage of gold sufficient to make it worth while to work them – in fact, these were the superficial *bonanzas* of the early explorers, as may be inferred from the relics of old opencast workings.

Two distinct zones may be noted in going from the surface downwards, although not observable in all the Pachuca veins: (1) the zone of oxides or *colorados*, and (2) the zone of sulphides or *negros*. In the uppermost are the oxides of iron (often gold-bearing) and oxides of manganese in abundance. In the

lower are the various metallic sulphides, such as those of iron, lead, silver, etc. Of the upper zone little is now left, and the mining of the present day in this district is all in deep workings.

The author proceeds to describe more in detail the mineralogy of the deposits, and points out that the manner in which manganese occurs in the veins shows that it made its appearance after the first deposition of quartz, carrying with it black argentiferous sulphides. Calcite was similarly a late arrival, as shown by its occurrence in small crystals within the geodes of quartz. Pyrites, galena, argentite, etc., seem, in most cases, to have been deposited simultaneously with the quartz, with which indeed they are so intimately commingled that they cannot be separated from it. On the other hand, the quartz without sulphides is completely isolated from the quartz with sulphides: the rich quartz and the barren form alternating bands, symmetrically disposed with regard to the metalliferous vein.

In the Santa Ana mine, where the Vizcaina vein is worked, at a depth of 505 feet, black sulphides form the infilling of irregular venules which traverse the quartz, thus showing that they were of later deposition. Subangular fragments of rock detached from the walls of the vein occur in it, at all depths. They are not packed close together, but appear to swim, as it were, in a sea of gangue—and around and upon each fragment the incrustation of quartz and metalliferous ores has proceeded with the same regularity as throughout the vein.

In the Santa Gertrudis vein, Barron mine, at a depth of 490 feet, there is an exceptional occurrence of splendidly crystallized barytes. Native silver is found at all depths.

As one goes deeper down in the mines, the oxides of iron are seen gradually to diminish, and the manganese oxides little by little give place to silicates. Pyrites is of such constant occurrence, in the country-rock in the neighbourhood of the veins ,that it has come to be regarded as a good indicator.

It is admitted as a general rule, holding good throughout the district, that the ores become poorer in depth. In many cases, the infilling is found to pass into practically barren blende: the ore is heavy, and has a good appearance, but the silver-percentage is so small that it does not cover the cost of working.

The deep workings are at the present time invaded by water, and there is urgent need of more powerful pumping-engines. When the mines are properly drained, it will be possible to pursue researches beyond the zone of barren blende, and the author thinks that rich ores will be found coming in again below it.*

L. L. B.

CARNOTITE, A NEW ORE OF URANIUM, COLORADA, U.S.A.

Sur un nouveau Minerai d'Urane, la Carnotite. By C. Friedel and E. Cumenge. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1899, *vol. cxxviii., pages* 532-534.

The mineral in question, which may prove to be of some industrial importance, was found in Montrose county (Colorado) by a French resident of Denver. It occurs in cavities at the surface of a grit, in association with the cupriferous ores, chessylite and malachite, and about 10 tons of the mineral have been got from this locality.

It is in the form of a yellow pulverulent substance, with no distinguishable crystalline structure, intimately commingled with quartz-sand. It stains the

* The author published a monograph on this district, "El Mineral de Pachuca, 1897," in the *Boletín del Instituto geológico de Mexico*, Nos. 7, 8 and 9.

fingers, and is easily separable from the silica by means of solution in dilute nitric and hydrochloric acids. The authors describe the method of analysis, whereby they eliminated silica, iron, alumina, etc., obtaining a residue of which the chemical composition is as follows:—

	Per Cent.
Uranium sesquioxide, U_2O_3	63·54
Vanadium pentoxide, V_2O_5	20·12
Potash, K_2O	10·37
Water, H_2O	5·95
	99 98

The percentage of silica varies from 2·6 (in very pure samples) to 60, and that of iron is also extremely variable, the yellow substance being in some places much richer in ferruginous venules than in others.

The mineral is named carnotite, in honour of Mr. Adolphe Carnot, French Inspector-General of Mines. L. L. B.

TESTING OF COALS BY RÖNTGEN RAYS.

(1) *Emploi des Rayons X pour l'Étude des Combustibles.* By H. Couriot. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1898, *pages* 222-223.

(2) *Examen et Analyse des Combustibles Minéraux par les Rayons X.* By H. Couriot. *Bulletin de la Société de l'Industrie Minérale*, 1898, *vol. xii.*, *pages* 713-726, *and* 3 *plates.*

(3) *Examen d'un Combustible Minéral au moyen des Rayons de Röntgen.* By H. Couriot. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol. cxxvi.*, *pages* 1588-1589.

Starting with the assumption that owing to the impermeability of silica and silicates to the Röntgen rays, the presence of ash-constituents of mineral fuels should be detectable by this means, the author examined anthracite, coal, lignite, peat, coke, and briquettes, and found that in all cases the minute structure of the mineral matter was revealed in clear detail as shadows on the screen. The transition between pure coal and slaty coal to true slate could be detected by this method; and in coke, the grains of iron sulphide from the pyrites were seen as black specks.

It is not necessary to shape the test-samples into regular blocks, the large fragments (1¼ to 2 inches thick) resulting from natural cleavage being sufficient to show the mineral skeleton of the fuel. The apparatus used consisted of a coil giving a 10 inches (25 centimetres) spark, with an independent interrupter and a Villard tube. J. W. P. and C. S.

(4) *Application des Rayons Röntgen à l'Examen des Combustibles Minéraux.* By J. Daniel. *Annales des Mines de Belgique*, 1899, *vol. iv.*, *pages* 3-16, *with figures in text.*

In order to obtain practical results from this method of investigation, the author submitted specimens of coal, coke, compressed fuel, etc, to the action of the Röntgen rays. The experiments were made by means of a coil with a 8 inches spark, furnished with an independent interrupter and a Villard coil; time of exposure, 1 minute. The specimens examined did not as a rule exceed $\frac{13}{16}$ inch in thickness. The effect of exposing the same specimen of coal in different planes was very noticeable. If the rays penetrated at right angles to the plane of

stratification, an extremely thin layer of shale arrested their passage, and consequently a dark tint under such conditions did not necessarily indicate a high percentage of shale, but on the other hand the transparency of a specimen so treated clearly showed its purity. If the rays fell on the specimen parallel to the plane of stratification, parts composed of pure coal were clearly differentiated from earthy or pyritic deposits. Exactly equal periods of exposure are essential for the comparison of radiographs. It is also necessary to take account of the exposure to sunlight. The thickness of the specimens examined is of capital importance, permeability to the Röntgen rays being greater in proportion to the thinness of the body traversed.

The process will be useful when it is desired to preserve the image of a sample of coal which has to be destroyed for analysis, as in the case of coal obtained from bore holes. The following method was adopted for determining the average ash-contents of ground coal. Finely powdered coal and shale were intimately mixed in proportions increasing by 10 per cent., and placed in an envelope of chemically pure paper having 11 cubical compartments, with pure coal at one end and pure shale at the other. This was submitted to the Röntgen rays and produced a scale of tints which are reproduced.

The writer also found that the Röntgen rays were applicable for the detection of flaws in iron plates up to 0·79 inch in thickness. Certain explosives have also been examined: the rays are interrupted by potassium nitrate and sulphur while wood charcoal is transparent. The author found that two samples of nitro-cellulose were absolutely transparent to the rays. W. N. A.

SOUNDING OF A DEEP SHAFT.

Markscheiderische Notiz zu den Schachtlothungen. By JOH. NĚMEČEK. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., pages* 610-611.

To survey and sink a shaft of great depth by means of two plumb-lines is one of the most difficult of mining-operations. The writer relates the results of such a survey at the Pribram colliery in Bohemia, in which little use could be made of modern instruments.

The Rudolph shaft in this mine formerly extended to the fifth level, at a depth of 450 feet, where it communicated with the Archduke Stephen shaft, about ½ mile off. It became necessary to sink it in its full dimensions, 6½ feet by 11½ feet, through the fifth, ninth, and eleventh levels, and a vertical depth of 650 feet. The Stephen shaft, from which the axis was determined, was wet, and the distance between the plumb-lines was only from 6½ to 7 feet. The line was surveyed at the three levels with 210 theodolite-stations, and an error of only 3 minutes in the survey would shift the position of the new shaft by nearly 3 feet; the length of the levels being from 3,200 to 3,500 feet. Local conditions prevented the triangles from being of the exact shape required, and it was also difficult to allow for the swing of the plumb-lines. The connexions having been determined, the shaft was sunk from level to level. At the ninth level, an error of 8·2 inches to the east was found, and at the eleventh level of 10·2 inches. The writer is of opinion that plumb-line soundings, even under unfavourable circumstances, are very useful, and apart from the costliness of the instruments, are preferable to optical surveys.

B. D.

A ROMAN MINE IN SOUTHERN HUNGARY.

Befahrung einer muthmaasslich römischen Edelmetallgrube bei Neu-Moldowa, Süd-Ungarn. By G. v. BENE. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1897, *vol. xlv., pages* 198-199.

Near a group of mountains called the Baronfels, in New Moldavia, there is an old mine, consisting of an adit-level and a shaft driven vertically from it, which is supposed to have been worked by the Romans. The writer had the opportunity of visiting it in 1896. Northwards from the Baronfels, about 1,500 feet above sea-level, are a series of depressions, overgrown with trees and brushwood. From the bridle-path, a short ascent leads to an artificial cutting in the limestone-rock, at the end of which the mouth of an adit-level 36 feet long and 6½ feet wide is visible. The level inside is larger than the adit, and is 62 feet long, 6½ feet wide, and about 5½ feet high. At 23 feet, a side gallery 20 feet long opens into it, which, like the level itself, has been carefully excavated with hammer and wedge. About 3½ feet from the floor, small niches have been cut in the walls, which were probably intended to hold little earthenware lamps for lighting the mine. This gallery terminates in a large open space where the roof is 12 to 13 feet high, and the irregularly-shaped walls denote the presence of a lode. A shaft has been sunk here, running south-west at an angle of 40 to 55 degrees. The writer had a strong wooden beam driven into a fissure and a rope attached to it. and he and his party were lowered one by one about 16 feet down, when a platform was reached. Magnetic iron-ore and manganite were observed in the walls at this part of the shaft, and no bearings with a compass could be taken, because the magnetic iron affected the needle. At the lower level, brown iron-ore, magnetic iron, copper pyrites and quartz were found in a granite-lode about 3 feet wide.

Proceeding down the shaft, at 60 feet below the upper gallery was a lower gallery, 70 feet long, which followed the lie of a lode running north-west, in a contrary direction, therefore, to the original lode. The two lodes seem to meet here. The floor and roof of the gallery consist of a tough stone, rich in quartz, and so smooth that it was difficult to walk over the slippery surface. At one part, where the floor sounded hollow, the writer laid bare with his hammer a layer about 4 inches thick of iron-ore, branching from the lode into the level. The road was blocked with tailings of quartz, granite, brown iron-ore, copper and iron pyrites and calcite crystals; but in a side gallery were found traces of blasting, showing that this part of the mine must have been worked in modern times. It was observed that no water had accumulated in the workings; probably therefore the lowest gallery and the main shaft must originally have communicated with other deeper levels.

The writer also examined a vertical open shaft, 6½ feet by 5½ feet, lying about 60 feet higher than the adit. Like the rest of the workings, this shaft had been wholly cut out with hammer and wedge, was absolutely perpendicular, with clean cut right-angled corners, and was truly a marvel of handiwork.

Many years ago, Roman pottery lamps were found in the upper gallery, one of which has been preserved in the Budapesth museum.

As mines in which silver-ore was found were known to exist farther south a few centuries ago, the conclusion may be drawn that all the hand-work which has been lavished even on the sterile rock in the open shaft, the adit, and the lower levels, is of Roman origin, and that the mine was worked to reach a lode of silver-bearing quartz-ore. Operations were carried on till within modern times, but apparently the lode has long been exhausted. B. D.

GOLD INDUSTRY OF DUTCH GUIANA.

Goldgewinnung in Niederländisch Guyana. By LUDWIG HENNECKE. *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate,* 1898, *vol. xlvi., pages* 252-253.

The gold-production of this colony scarcely received all the attention that it deserved until 1896, when a committee was formed for the purpose of undertaking a thoroughly exhaustive geological and economic survey of the country lying between the two great rivers. This survey will be completed in 4 years from its commencement, and the committee have obtained from the Dutch Government, in addition to pecuniary support and expert assistance, the right to exploit all the country surveyed by them and to build a railway.

The value of the gold exported from Dutch Guiana from the inception of the industry until the end of 1896 was £1,724,532 (20,694,380 gulden). The amount of gold produced in the colony in 1896 was 27,087 ounces (846,467 grammes), and in 1897 the amount was 22,164 ounces (692,621 grammes), two-thirds of which came from the Surinam district. The precious metal ranks highest in the list of exports, next to cocoa and sugar. Indeed, it is to the gold-industry that the colony owes such progress as it has achieved during recent decades, and should the survey now approaching completion yield favourable results in this respect a great influx of European capital and immigrants may be anticipated. Even now, the demand for labour exceeds the supply. The author controverts the widespread notion that the climate is unhealthy. L. L. B.

EXTRACTION OF A BROKEN ROD FROM A BORE-HOLE.

Entfernen von Eisenbruchstücken aus einem Bohrloch. ANON. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1898, *vol. xlvi., page* 250.

The end of a boring-rod broke off in a hole about 1,000 feet (300 metres) deep, put down in the Gleiwitz district; and boring was interrupted through the diamond crowns being ground against the pieces of steel. After three weeks of fruitless endeavours to remove the obstruction, Mr. Degenhardt extracted the pieces by means of a powerful magnet. A bar of soft iron 59 inches (1·5 metres) long, and 2¾ inches (7 centimetres) in diameter, was wound with insulated wire; and, after the bar had reached the bottom, a current of about 30 ampères was sent through the winding from a small dynamo driven by the portable engine used for boring. On the same day that the bar was let down, it was drawn up with the pieces of rod fast adhering to it. J. W. P.

ROCK-DRILLING MACHINERY.

Die Erweiterung und Regulirung des Wolfdietrichstollens am k.k. Salzberge zu Dürrnberg der k.k. Salinen-verwaltung in Hallein. By PAUL SORGO. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1897, *vol. xlv., pages* 625-631, *and* 1 *plate.*

The Wolfdietrich adit, the deepest level in the Dürrnberg salt-mine at Hallein, was first worked in the year 1796, at a distance of over 1½ miles from the mouth of the adit. As this level was too small for modern requirements it was enlarged and improved in 1894, and the rock-drills were driven by electric motors. The plant consists of a 10 horsepower turbine coupled direct to a dynamo, from which the electric current is led through the length of the level, and applied to drive two Siemens rock-drills.

The water to provide power for the dynamos is obtained from a spring in the mine, yielding from 26,000 to 440,000 gallons per 24 hours, and from surface-water drawn from a spring at some distance, with a fall of 572 feet.

The electric motor is contained in a strong wooden box, which can be moved about as required. With a tension of 220 volts and 6 ampères, 1 brake-horse-power is obtained. The power is transmitted to the drilling-machines by cog-wheels connected to the end of a flexible shaft, and undue strain on the machine is prevented by a friction-coupling. The flexible shaft is about 7¼ feet long, and consists of a number of small concentric steel spirals, coiled round a strong steel wire, and of a single spiral covered with leather, and with guides at either end. The two ends of the shaft are coupled to the rock-drill and to the motor respectively, by socket, clutches, and ball-bearings.

From the flexible shaft, the motion is transmitted through a fly-wheel to a crank driving a crosshead and piston working through a stuffing-box. The piston is hollow, and the boring-chisel fits into it, so that it cannot turn round except with the piston. As the crank rotates, a to-and-fro motion is imparted to the piston, and there are two springs which give such elasticity to its stroke that it goes much further into the rock than the actual stroke. The machinery is adjusted and started by a hand-crank, and the position of the drills is varied by screws. The piston makes about 450 strokes per minute. It is hollow, so that the drill can be drawn out through it, and changed, if required, without moving the frame, but this is seldom necessary.

With a tension of 240 volts, one drilling-machine usually requires a force of 5 ampères. Four men are employed, working 10 hours a day. In May and June, 1897, 572 holes were drilled, and a total depth of rock pierced per day of 27½ feet, or about 11 feet per man per day. With a hand-drill, the depth bored was about 3 feet per day, or 3·4 times less than with the electric drill. All the work was piecework, and the total cost of drilling was about 3d. per cubic foot. B. D.

SCHAUB ELECTRIC COAL-CUTTING MACHINE.

Schlitz- und Schrämmaschine mit elektrischem Antriebe, Patent Johann Schaub. By V. Waltl. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., pages* 677-680, *and* 1 *plate.*

The writer describes the Schaub electrically-driven coal-cutting machine which has been used to undercut in a mine in Poland, and has also been successfully applied in a lignite-mine in Austria.

A small carriage mounted on wheels carries a toothed wheel driven by the motor-crank, and gearing into two others, one on either side. These actuate two endless-chains, each connected to a vertical frame carrying three drills one above the other. The two frames are united to the central carriage, and their distance from it can be varied at will. They may also be raised or lowered vertically, the one descending as the other ascends. The chains act directly upon the spindles of the drills. Both sets of drills can be worked at the same time, or one or the other thrown out of gear. The two frames are moved out from the central carriage by means of a series of wheels gearing into a right and left-handed horizontal screw, which runs the length of the machine, and carries the frames at either end. The turn of a crank-handle varies the distance between them. Each of the frames is in duplicate, that is, there are on either side two frames, one beyond the other; the inner one alters the vertical, and the outer one the horizontal position of the drills.

The two toothed wheels which transmit the motion to the drill-spindles from the motor-shaft are connected to rollers on which the endless-chain revolves; the other end of the chain passes over another roller on the outer frame carrying the drills. The action is so regulated by means of chain-wheels attached to the rollers that all three drills of one set are driven forward at once. The vertical movement is obtained by a rack-and-clutch gear worked by two small shafts moving in a hollow groove and actuated by worm-gearing and right and left-handed screws. The movement is facilitated by an elaborate arrangement of levers, friction-coupling, and ratchet-wheels.

By these and other means, the drills are kept constantly rotating, and are worked alternately up and down in sets. As soon as they have reached their highest or lowest position, they are pushed forward into the rock, and the action is repeated in the contrary direction. It is also possible to move the drills back, or to work them rapidly backwards or forwards, as is sometimes required when shifting their position in narrow levels. Special levers and nuts are supplied for this object. The stroke of the drills is carefully adjusted according to the excavations required. To remove the rock as it is worked, the lowest drill in each frame has a revolving screw which pushes back the rubbish. The drill itself consists of four knives set round the spindle at different angles. When used in the Piberstein lignite-mine in Bohemia, the machine was driven by a Siemens and Halske dynamo, and worked well. The original paper is illustrated by drawings. B. D.

THE THEORY OF SAFETY-EXPLOSIVES.

Weiteres zur Frage der Sicherheitssprengstoffe. *By* — HEISE. *Glückauf*, 1898, *vol. xxxiv., pages* 657-664, 684-691, 709-714, *and* 721-726.

The author has calculated the temperature produced by the detonation of a number of explosives, the quantity of heat evolved, and the amount of mechanical work corresponding to that heat. He calculates the heat evolved as follows:—The quantity of heat evolved in any explosion is equal to the difference between the heat of formation of the ultimate and of the original compounds. The heats of formation of the ingredients of the ordinary explosives and of the compounds produced by their explosion have been fairly well determined, though in some cases the precise reactions involved may be somewhat doubtful. The heat thus calculated refers, however, to constant pressure; but as detonation is practically instantaneous, no time is allowed for expansion, hence an amount representing the additional quantity of heat at constant volume must be added to the above in order to obtain the total amount of heat set free; the latter consideration adds about $1\frac{1}{8}$ to $1\frac{1}{2}$ per cent. to the amount of heat first calculated.

The temperature is obtained from the wellknown formula:

$$t = \frac{Q}{c}$$

where t is the temperature, Q the quantity of heat and c the mean specific heat of the products of the explosion. In the case of gases this expression becomes, according to Messrs. Mallard and Le Chatelier:

$$t = \frac{Q}{a + bt}$$

where a and b are constants varying for the different gases.

The theoretical work that an explosive is capable of performing is by the Carnot law:

$$A = 425\ Q \left(\frac{1 - 15^{\circ}}{t}\right)$$

where A represents the amount of work done in kilogrammetres, and t is the temperature in degrees Cent., the mean temperature of the atmosphere being taken at 15° Cent.

The author thus calculates Table I.

TABLE I.

Explosive.	Composition of Explosive.		Calculated Temperature of Detonation.	Calculated Power in 1 Kilogramme of Explosive.
	Per Cent.		Degs. Cent.	Kilogram-metres.
Kohlen-karbonit and Wittenbergen wetterdynamit	25·0	Nitro-glycerine	1,845	231,000
	34·0	Potassic nitrate		
	39·5	Flour (including 2·5 per cent. of moisture)		
	1·0	Baric nitrate		
	0·5	Sodic carbonate		
Kohlen-karbonit I.	25·0	Nitro-glycerine	1,868	239,000
	30·5	Sodic nitrate		
	39 5	Flour (including 2·5 per cent. of moisture)		
	5·0	Potassic bichromate		
Kohlen-karbonit II.	30·0	Nitro-glycerine	1,821	232,000
	24·5	Sodic nitrate		
	40·5	Flour (including 2·5 per cent. of moisture)		
	5·0	Potassic bichromate		
Köln-Rottweiler sicherheits-sprengpulver	93·0	Ammonic nitrate	1,774	265,000
	4·9	Oil		
	1·2	Sulphur		
	0·9	Baric nitrate		
Dahmenit A	91·3	Ammonic nitrate	2,064	341,000
	6·475	Naphthalin		
	2·225	Potassic bichromate		
Roburit I.	87·5	Ammonic nitrate	1,616	220,000
	7·0	Dinitrobenzol		
	0·5	Potassic permanganate		
	5·0	Ammonic sulphate		
Westfalit	91·0	Ammonic nitrate	1,806	274,000
	4·0	Potassic nitrate		
	5·0	Resin		
Gelatine-dynamit	62·5	Nitro-glycerine	2,984	491,000
	2·5	Nitro-cellulose		
	25·9	Sodic nitrate		
	8·75	Cellulose		
	0·75	Sodic carbonate		
Guhr-dynamit	75·0	Nitro-glycerine	2,907	427,000
	25·0	Kieselguhr		

It will be shown that the degree of temperature of the explosions does not directly determine the safety of the explosive, and that the theoretical force of the explosive cannot be applied to the determination of its practical efficiency. In addition to its force, its shattering power or the rapidity with which its force can be exerted, has to be considered. Subsequently it will be shown how the shattering power can be determined and what the relations are that probably subsist between it, the force, the safety and the temperature of explosion of any explosive.

A large number of experiments were tried to determine the degree of safety of various explosives, or the maximum quantity that could be fired without causing ignition of (*a*) coal-dust alone in air or with 2½ per cent. of fire-damp, (*b*) 6½ per cent. of fire-damp and air, and (*c*) 8 per cent. of fire-damp and air, with coal-dust in both cases. The shots were fired from an unstemmed cannon into the mixtures. The experiments are recorded in detail in the original communication, and their results are shown in Table II.

TABLE II.—RESULTS OF EXPERIMENTS.

EXPLOSIVES.	(*a*) With Coal-dust alone, or with 2½ Per Cent. of Fire-damp.		(*b*) With Coal-dust and 6½ Per Cent. of Fire-damp.		(*c*) With Coal-dust and 8 Per Cent. of Fire-damp.	
	Safe with Grammes.	Unsafe with Grammes.	Safe with Grammes.	Unsafe with Grammes.	Safe with Grammes.	Unsafe with Grammes.
1. Kohlen-karbonit ...	—	—	—	—	900	—
2. Kohlen-karbonit I....	—	—	—	—	725	—
3. Kohlen-karbonit II.	—	—	—	—	735	—
4. Köln-Rottweiler sicherheits-sprengpulver	500	550	400	450	200	250
5. Dahmenit A.	550	600	450	500	450	500
6. Do. compressed and granulated ...	—	—	—	—	700	—
7 Roburit I.	450	500	450	500	300	350
8. Westfalit	550	600	450	500	350	400
9. Phœnix I.	—	—	—	—	800	—
10. Phœnix II.	—	—	—	—	800	—
11. Phœnix III.	—	—	—	—	800	—

Gelatine-dynamite fired in the same way ignites coal-dust with a minimum charge of 50 grammes, but if an iron plate is set up firmly between 3 and 21 inches away from the mouth of the cannon, so that the air with its suspended coal-dust was greatly compressed at the moment of explosion, ignition could be produced with as little as 10 grammes of gelatine-dynamite; the direction of the bore-hole underground, *i.e.*, whether it points along a drift or across it, will make a difference in the behaviour of a blown-out shot.

Black-powder fired unstemmed by means of a detonator ignited coal-dust, with a charge of 70 to 80 grammes; if fired by means of a fuse without a detonator, 250 grammes were required to ignite the dust; again, if the charge be tamped with 4 inches of dry clay, the degree of danger of the powder again increased, as a charge of 200 grammes then sufficed to ignite the coal-dust.

Somewhat analogous results were shown by firing explosives freely supported in an atmosphere of gas and coal-dust; the author condemns this method of

experimenting, because he finds that the explosion is apt to be incomplete and that explosives which possess the good property of being readily and completely exploded therefore show relatively unfavourable results.

The author gives a series of tests of the shattering-power of the various explosives by the Trauzl method, using first of all 10 grammes of each explosive, and secondly, such an amount as he calculates will develop 2,500 kilogrammetres of force; he shows that the force actually developed in the Trauzl block and that calculated do not stand in any relation to each other, and he calls the latter the shattering-power (*brisanz*).

He discusses the cause of the safety of explosives, and points out that a high measure of safety is closely related to low shattering-power; he considers that the increased danger due to increased weight of charge is due to the greater amount of compression thus produced, because the heat developed by compression may in itself be a source of danger, whilst a mixture of explosive gas is also fired more readily under high than under low pressures. He concludes that improvements in safety-explosives should be directed to producing the maximum of power at a temperature of detonation that does not exceed the danger-limit of 2,200° Cent., and to regulating the shattering-power so as to attain a definite measure of safety. A perfectly safe explosive is an impossibility. H. L.

EXPLOSIVES IN BELGIAN COLLIERIES.*

Emploi des Explosifs dans les Mines de Houille de Belgique pendant l'Année 1897. *By* Victor Watteyne and Lucien Denoël. *Annales des Mines de Belgique*, 1898, *vol. iii.*, *pages* 777-857.

Between 1895 and 1897, the intensity of blasting fell from 27 to 25 for slightly fiery mines, from 14 to 12 for decidedly fiery mines, and from 3 to 1 for those subject to sudden outburst of fire-damp.

Comparative tables show that, although there is the apparent increase from 31 pounds (14 kilogrammes) in 1895 to 35 pounds (16 kilogrammes) in 1897 for decidedly fiery mines in the Couchant de Mons district (which increase is explained by the fact that mines formerly classed as but little fiery are now included in the decidedly fiery class) in all the other districts the diminution is shown to be general and considerable, the consumption of explosives for ripping roof and floor in the country collectively having fallen to 2·2 pounds (1 kilogramme) per 1,000 tons of coal raised. Again, while in 1895, the proportion of slow explosives used for driving roads in decidedly fiery mines was 62 per cent. of the whole quantity of explosives used, this proportion fell to 20 per cent. in 1897. At several collieries in the Couchant de Mons, Charleroi and Liége districts the use of explosives has been either entirely abolished or very considerably reduced.

Although the new Mines Regulations of December 13th, 1895, do not explicitly mention safety-explosives, they implicitly refer to them in the following terms:—"It is such, and not ordinary high explosives, that wise managers will use in fiery working-places, when they can not entirely suppress the use of explosives.

From a theoretical standpoint, the cause of the greater or less degree of safety possessed by explosives in the presence of fire-damp and coal-dust must be sought in the different intervals between delay in ignition and that of the complete cooling of the explosion-products. The chief influences on which the extent of this difference depends are the rapidity of the explosion and the detonation-tempera-

* *Trans. Inst. M.E.*, vol. xiv., page 638.

ture; but they are too imperfectly defined, and their interdependence is too complex, for any limits compatible with safety to be assigned with certainty. For a given explosive, the degree of safety, always relative, depends upon the weight of it that is detonated together with external circumstances; and there exists for every explosive a limit of charge beyond which the ignition of fire-damp or coal-dust must inevitably occur.

From a practical standpoint, a limit of charge constitutes the most rational standard by which to measure the degree of security afforded by the various explosives; and it should be determined empirically, under danger conditions as similar as possible to those prevailing in fiery and dusty mines. A safety-explosive is characterized by a sufficiently high limit of charge and one comparable with those required by the use for which the explosive is destined. The most economical explosive is that which, in addition to the greatest degree of safety, possesses the highest explosive power and also that best suited to its object; and these conditions, which are not absolutely contradictory, may be realized by a suitable combination of the detonation-temperature and the balistic power.

J. W. P.

ACCIDENT THROUGH OPENING A BOX OF DETONATORS.

Explosion von Sprengkapseln am Tiefbauschachte bei Mährisch-Ostrau. By DR. FILLUNGER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1899, *vol. xlvii., pages* 16-17.

At the Witkowitz colliery, near Mährisch-Ostrau, a carpenter was called in to the explosive magazine to open a box containing 2,000 No. 8 and 3,000 No. 6 detonators; but, only 110 seconds after his entrance, an explosion occurred. On the magazine being entered by men wearing pneumatophores, the body of the store-keeper was found, and also that of the carpenter, torn into shreds; and a hole in the middle of the cemented floor appeared, 19 inches (0·5 metre) deep and about 10 square feet (1 square metre) in area. The time of 110 seconds was afterwards found by trial to be just that required for taking out the screws of the outer case; and it is supposed that, for removing the screws from the inner box, one of them was first turned a little from left to right in order to ease its extraction, and that the point of the screw, carelessly directed so as to come out inside the box, had on being turned exerted a pressure on a detonator, this supposition being confirmed by several boxes having since been found thus imperfectly closed. J. W. P.

SINKING A SHAFT UNDER DIFFICULTIES.

Das Abteufen des Schachtes II. der Zeche Victor bei Rauxel. By BERGREFERENDARS PIELER AND HENNENBRUCH. *Glückauf*, 1899, *vol.* XXXV., *pages* 41-49, *with plans and sections in text, and two plates.*

The sinking, between 1894 and 1898, of the No. 2 shaft at the Victor colliery, Westphalia, in the immediate neighbourhood of the No. 1 shaft, possesses special interest from three points of view, namely, the efforts made to sink the shaft with insufficient pumping power; the boring and tubbing thereof to the largest diameter yet adopted with the Kind-Chaudron method; and the works carried out for closing off the water, which was not completely excluded by the moss stuffing-box.

Sinking by excavation from the surface was begun in February, 1894; and at the same time, in order to hasten the work, upward drivings were started from the

return-airway and also from the first and second deep levels of No. 1 shaft. A sinking-cylinder with cutting-shoes, 20 feet (6 metres) in diameter, was got down without difficulty to a depth of 60 feet (18 metres), when it canted out of the vertical owing to the resistance being greater on one side than on the other, while cracks showed themselves in the tower, and the cutting-shoe broke at two places. In order to restore the verticality, a further depth of 23 feet (7 metres) was excavated, the cutting-shoes underwalled, and a masonry-lining of the finished diameter, 17 feet (5·2 metres), carried up to the surface.

Further sinking, partly with the aid of gelatine-dynamite, was continued to a depth of 751 feet (229 metres), without great difficulty, 95 feet (29 metres) being sunk and lined per month on an average. In the middle of November, 1894, however, a shot-hole put into the bottom of the shaft struck a water-bearing fissure yielding about 220 gallons (1 cubic metre) per minute, when sinking was stopped in order to permit of a connexion being made with the upward drivings from the lower levels, in order to afford means for drawing off the water, communications between the first and second deep levels being made in January, 1895. The hole, about 229 feet (70 metres) deep, to be put down from the bottom of the shaft to the upward driving from the return-airway, was bored of a diameter of 4⅛ inches (105 millimetres), with a combined rope-and-rod method and the Fabian free-fall device, when sinking was resumed for a further depth of 39 feet (12 metres), thus laying the fissure bare to such an extent that the water increased to more than 1,320 gallons (6 cubic metres) per minute, a larger quantity than could be dealt with by the pumping-engine of No. 1 shaft.

Ultimately, at a depth of about 804 feet (245 metres), the quantity of water amounted to 4,620 gallons (21 cubic metres) per minute, and might be expected to increase as the shaft got deeper, when it was decided to sink the remaining depth by the Kind-Chaudron system.

The above-named bore-hole served to guide the small trepan, which was cast in one piece from Krupp steel, to a width at the chisel-edge of 8½ feet (2·6 metres), and fitted with 19 crucible cast-steel chisels that could be renewed separately, while a cone was substituted for the middle tooth. The small trepan, the total weight of which was 7½ tons, was also connected with a Kind free-fall device, and so articulated that only the chisel-edge canted to any inequalities of the bottom, a precaution adopted so as to prevent breakage of the rods. The large trepan, 16½ feet (5·04 metres) wide, was built up of several cast-steel parts, the 12 boring-teeth being distributed at the two ends of the chisel-edge and the space in the middle being occupied by a curved timber guide corresponding to the diameter of the shaft that had been bored by the smaller trepan. The chisel-edge was strengthened by two arms proceeding upwards from the ends in an inclined direction; and on account of the great weight of the large trepan, namely, 26 tons, a sliding-joint was used instead of the free-fall device.

The small trepan encountered great difficulty, first, from the many parts of tools and pieces of wood that had fallen into the pit-bottom, which could not be fished up, and afterwards by the numerous hard nodules in the marl, which necessitated frequent renewal of the teeth. The mud from boring was allowed to run into the central bore-hole until it became filled; and then the mud was taken out by the spoon. A connexion between this small central shaft and the upward driving from the return-airway was effected on February 4th, 1896, 17 inches (44 centimetres) having been bored daily on an average; and, inasmuch as the upward driving had naturally become filled up, a further depth of about 42½ feet (13 metres) was bored.

Work with the large trepan, which began on March 1st, 1896, was greatly interfered with by the fissure turning aside the trepan, so that a second boring out had to be effected with scraping teeth, whereupon the rods frequently broke, which it was first attempted to counteract by guiding them, and afterwards with greater success by increasing their strength. As it was thought too dangerous, on account of the large influx of water, to allow the mud from the boring to run into the workings below, it was raised to the surface by the spoon; and during the latter portion of the time it became necessary to employ rods instead of a rope because the mud was very stiff. At length, on December 10th, 1896, the shaft, bored to its full diameter, reached the Coal-measures at a depth of 989 feet (301·5 metres), nearly 8 inches (20 centimetres) having been bored daily on an average.

Inasmuch as it was not possible to form a smooth surface for receiving the moss stuffing-box on the Coal-measures owing to their hardness, a layer of concrete, 2 feet 3 inches (70 centimetres) thick, was laid on the bottom of the shaft and made level by a timber beam attached below the small trepan.

Inasmuch as, for facilitating the insertion of the tubbing, two attempts had failed to pump the shaft full of water, a platform was put up just above the water-level, as otherwise the weight on the sinking-rods would have been far too great; and, round the platform, the sides of the shaft were widened out with the pick in order to afford the men room to work, while a cross-cut 10 feet (3 metres) long was driven for them to retreat into when the cast-iron tubbing rings were being let down.

The cast-iron tubbing rings, 4 feet (1·2 metres) high and 15 feet 7 inches (4·75 metres) in diameter, were made in seven series, their thicknesses varying between $3\frac{9}{16}$ inches (90 millimetres) and $2\frac{27}{32}$ inches (72 millimetres), so as to weigh from 13·3 to 11·3 tons, and to stand pressures varying from 42 to 36 atmospheres, respectively.

The moss stuffing-box consisted of an inner ring in one piece, like the tubbing rings, but a little higher, with six slight projections outside the upper edge, engaging with corresponding grooves in the outer ring, which was cast in six segments and put together with bolts and leaden packing, being also of slightly greater height. The inner ring was turned with a shallow groove on the outside, for receiving the ten segments of the wedging-crib, all these three members being $3\frac{9}{16}$ inches (90 millimetres) thick. Between the wedging-crib and the outer ring moss packing was rammed, having been kept in place by wire netting while being let down.

Inasmuch as the shaft was lined water-tight for a depth of about 754 feet (230 metres), only that portion between the bottom of the walling and the bottom of the shaft was tubbed, being fitted with an equilibrium-pipe and a cover at both top and bottom, so that a saving was effected of about 330 feet (100 metres) of tubbing.

The actual length of tubbing put in was 243½ feet (74·2 metres), composed of ten rings each from the strongest and the weakest series, with eight rings each of the remaining series; and the total weight, including the moss stuffing-box with packing, screws, leaden jointing and covers, was 870·889 tons.

The work of putting in the stuffing-box, let down by six rods, was begun on February 4th, the rods having been, on account of safety, retained until the 24th ring was put in, although calculations showed that the tubbing must float on the 15th ring being added. As the further rings were added, water was allowed to flow into the tubbing so as to keep it at a determined height. By March 13th, all the rings with the cover had been inserted; and the tubbing was then forced

down with the sinking apparatus, until it was found that the layer of concrete had become covered with about 10 feet (3 metres) of mud, etc. There was then great hesitation about opening the valve in the cover, because of the doubt as to a tight stopping-off of the water having been effected; and the question arose whether the whole tubbing should be taken out and the ledge cleared, or whether, on the valve being opened. the tubbing would force its way down upon its bed. It was ultimately decided to open the valve, when the stuffing-box went down about 10 feet (3 metres) so that apparently a tight joint had been formed; and, therefore, concrete was run in between the tubbing and the inside of the shaft.

After the lapse of six weeks, attempts were made to take the water out by water-tubs; but, on the cover of the tubbing being reached, at the depth of 744 feet (227 metres), and unscrewed, it was found that the upper lengths of the equilibrium-pipe were filled at the top with unhardened concrete and underneath with the mud from boring, which led to the supposition that either the stuffing-box and concrete still allowed water to pass, or that the box had not descended upon the ledge. On the third length of pipe being taken down, water issued at the rate of 286 gallons (1·3 cubic metres) per minute, when the attempts made to take the water out by tubs were resumed. This course was, however, abandoned as the quantity of water increased; and it was determined to bore a hole from the Coal-measures to the bottom of the shaft, which rendered necessary the erection of a powerful pumping-engine at No. 1 shaft, in order to preserve the mine from the danger of flooding.

Under great difficulties a hole was bored upwards, from a chamber blasted out of the hard sandstone at the end of a curved drift from No. 1 shaft, into the bottom of No. 2 shaft, which was thus at length cleared of water, the hollow boring-rods being left in the hole for that purpose. After the moss stuffing-box had been securely fixed, the shaft was sunk deeper; and it was found, on the layer of concrete being removed, that the box had sunk 1 foot 7 inches (0·50 metre) into the concrete which, though hard in the middle, could be taken out by the pick at the outside, while the box had also arrived within 19 inches (0·50 metre) of the Coal-measures.

The want of tightness is attributed to the following causes:—The space between the stuffing-box and the inside of the shaft was about 4 inches (10 centimetres) wide, whereas the moss-packing was only calculated for a width of 2⅜ inches (6 centimetres). At the place where the box allowed water to pass, the concrete had not hardened owing to the presence of mud; and, when the water was taken out to the depth of 787 feet (240 metres), the marly water, subjected to a pressure of more than 10 atmospheres, forced through the soft concrete to the inside of the shaft, underneath the stuffing-box, made its way into the hollow space, and passed out by the equilibrium-pipe.

A double wedging-crib was laid 20 feet (6 metres) underneath the moss-box to carry seven tubbing rings, that were screwed up and backed with concrete, and the space between the uppermost ring and the under side of the box was carefully wedged tight, so as to completely stop off the water. For greater security, a second double wedging-crib was laid in hard sandstone 18 feet (5½ metres) deeper, and connected with the other in a similar manner. Ultimately, the sinking and lining of the shaft were completed down to the return-airway 1,181 feet (360 metres) deep, after having occupied 4½ years.

J. W. P.

COMPARISON OF PROPS FOR MINE-TIMBERING.

Ueber die Gebrauchsfähigkeit einiger Holzarten zum Grubenausbau. By CH. DÜTTING. *Glückauf*, 1898, *vol. xxxiv.*, *pages* 797-803.

The main object of the experiments made at the Prussian State collieries, Saarbrücken, was to ascertain the value of beech-props and the suitability of acacia (*Robinia*) for timbering. Beech-props are reproached with having but slight resistance, being brittle and breaking off short under crushing-strain, of being heavy so that they are difficult to handle underground, of tendency to rapid decay, and of giving no warning by a cracking noise before yielding to pressure.

It was arranged, in the trials, to use only props of the dimensions usual in mines, *i.e.*, about 5⅔ feet long, and for compression-tests only sound props of as nearly uniform diameter as possible. Props of various timbers were exposed for various periods to both intake air and return air-currents, several specimens of each timber and also of each kind of prop being tested.

Normal props were found to break with loads varying from 25 to 28 tons, under which they nearly all bent laterally, even if only 3¼ feet (1 metre) long and 4 inches (10 centimetres) in diameter, while breakage nearly always ensued through crushing. Calculations of the resistance to crushing-strain per unit of cross-section permitted the author to compile a series of tables, from which he deduces the following particulars.

The strength of the various timbers increased with drying. Some of the dried props were placed on the shale-tip, others in an intake air-way, and others again in a main return air-way; and after 3 months it was found that the strength of the first had increased, and that the second and third had lost in weight and strength, the third more than the second. As regards warning before breakage fir occupies the first place, followed in order by pine, beech, and oak. While the warning noise given by beech only begins with fracture, fir especially, and pine in a less degree, give a slight cracking noise before the commencement of breakage.

Beech-timber is indeed under-estimated as regards its strength and warning capability, while oak has been over-estimated—at any rate as regards its strength. When beech may be obtained at reasonable prices, this timber may certainly be used for props in the second working of coal when they only have to stand for a short time. Removing the bark favours drying, which increases the strength and capability of warning; and dry woods give earlier warning than those freshly cut. The more resin there is in a wood the slighter will be its strength; and fir props generally break at the resinous knots, while in deciduous trees the strength is less impaired by branches and cracks than by crooked grain.

The trials at the König colliery were extended to acacia, which is said to thrive well on poor soils, and to yield mine-props 15 or 20 years after the main stem is cut. It was found that acacia-props used in the second working showed a strength equal to that of fir-props; and still more favourable results were obtained by using the acacia for timber sets in places that have to be kept up a long while. Some return air-ways were timbered with fir, oak and acacia in succession; and, after 5 months, no change was noticed in the last-named, while decay had begun in the sap-wood of the oak, and some of the timbers in the fir sets were already broken. The advantage of acacia for mining purposes, however, must be sought less in its strength than in its power to withstand the underground atmosphere.

J. W. P.

SHAFT-CLOSING ARRANGEMENTS.

(1) *Ueber Neuerungen an Bremsschachtverschlüssen. By* P. J. *Glückauf,* 1898, *vol. xxxiv., pages* 105-107, *and* 2 *plates.*

The mine regulations of the Dortmund Mines-inspection District provide that each separate winding-compartment shall be fitted at every landing with a sliding-door moved by the onsetter, or with a lattice-work door opened and closed by the onsetter or by the cage itself; and, in addition to this, every winding-compartment must be closed by an iron rod at a height of 8 inches (20 centimetres) above the top of the tubs, whenever a winding is being made.

The protection afforded by the rod is insufficient; and slight injuries, especially to the hands, may be directly attributed to its use. During the last three years, several collieries have been fitted with automatic fences, which meet all requirements, notably the following :—(1) The men are ensured against falling down the shaft; and with this object arrangements have been devised which compel the men to close the fence before the cage can leave the landing, and when once closed the fence cannot be re-opened by them. (2) A thrusting out of the head, hands, etc., into the shaft is rendered impossible when the cage is in motion. (3) The cage is made fast while the tubs are being pushed on and drawn off, so as to prevent accidents from occurring should the brakesman take off the brake during these operations. (4) Winding in the shaft is not interrupted by the closing arrangement. And (5) the fences are so constructed that their working is not interrupted by slight displacement of the shaft-lining owing to thrust of the measures.

(2) *Einfach konstruierter Bremsschachtverschluss.* ANON. *Glückauf,* 1898, *vol. xxxiv., pages* 206-207, *and plate.*

This shaft-closing arrangement, invented by Bergassessor Morsbach, may be applied to either swing or sliding-doors; and the fence is constructed so that the arrangement can only be opened when the brake is applied, and movement of the cage in the shaft is only possible when all the gates are closed. The desired result is attained, on the one hand by means of an iron rod attached to the brake-lever, provided with cranks or recesses, and on the other by a projection fitted to the gate preventing the latter from being opened until a slot comes opposite the projection into which the latter can enter. For this purpose, the rod must be raised to a certain point for each landing, because the cranks or recesses are so arranged that only one door can be opened at the same time. Moreover, the brakesman cannot take off his brake before the door is closed, otherwise the gate-projection within the recess would immediately be held fast by the bolt-rod of the brake. Provision is made for preventing any failure of the arrangement in the event of displacement of the shaft-lining as the result of pressure. The advantages claimed are as follow :—(1) The brakesman operates the brake and fence by one and the same movement of his hand. (2) The cross-section of the shaft remains entirely open. (3) The arrangement is so simple that it may be made in the smithy of any colliery. (4) A positive, exact action, and therefore certain working, of the fence is secured. (5) Neither the onsetter nor banksman can clamp any part fast so as to impair the efficiency of the arrangement. (6) The fence may be opened by the brakesman before the cage comes quite down to the landing—for instance, when timber is being taken down.

J. W. P.

NEW HYDRAULIC KEPS.

Charbonnages du Grand Hornu: Taquets Hydrauliques. By — NIBELLE. *Annales des Mines de Belgique*, 1898, *vol. iii., pages* 140-142, *with vertical and horizontal sections.*

Each cage, with four decks carrying two tubs end to end on a deck, comes down upon four keps carried by plungers, each moving in its cylinder; and the cylinders corresponding with the two keps on one and the same side of the cage communicate with one another by a pipe of sectional area equal to that of the plunger, and bolted by flanges to the undersides of these two cylinders. Two ¾ inch (19 millimetres) brass pipes, laid horizontally inside the shaft, also connect this system of two cylinders with that of the two other cylinders diametrically opposite in the other winding compartment. Each of these brass pipes is provided with a cock; and their two keys, or spanners, are so connected that they can be worked from the landing by a single crank handle, for intercepting or re-establishing hydraulic communication between two of each of the four sets of keps. Supposing the cocks worked by the crank handle to be closed, and the four keps corresponding with one cage at the top of their travel, ready to receive a cage at the level of the lower floor of the landing; then the remaining four keps, corresponding with the other cage, will be at the bottom of their travel. When two decks of the descended cage have been loaded, the cocks will be opened by the crank handle to a certain extent; and the four keps that are at the top of their travel will, yielding to the weight of the cage, descend 3 feet 7 inches (1·1 metres) which is the distance between two decks, and will cause the remaining four keps to rise correspondingly, so as to be ready to receive the next cage, the cocks having been closed.

The above-named diameter of the brass communication pipes is calculated so as to oblige the water within it to acquire a speed of 69 feet (21 metres) per second, the friction of which sets up a resistance that about balances the weight of the cage and its load, and permits the plungers to come down gently. The cylinders, which were tested to 779 lbs. per square inch (53 atmospheres) are fitted with a safety-valve, which rises under a pressure of 735 lbs. per square inch (50 atmospheres), in order to prevent breakage in the event of the cage coming down too sharply upon the keps. In such a case, the water escaping by the valve would be restored at the next operation; and the decks that passed the landing-level would not be loaded, the other decks only being loaded by letting down the kep-plungers to the bottom of their stroke by opening the cocks. The keps of the other winding compartment would rise to a certain height, but not to the top of their travel on account of the water that had escaped. The two communication pipes would then, by the opening of cocks, be connected with a head of water, under the influence of which the kep-cylinders not loaded would be brought up to the top of their stroke, owing to the weight of the cage keeping the others at their lowest position.

J. W. P.

WINDING ACCIDENTS IN THE OBERHAUSEN DISTRICT.

Betriebsstörungen bei der Schachtförderung. By D. *Glückauf*, 1898, *vol. xxxiv., page* 987.

In the first case, the cage was drawn with great force up to the pulleys, while the other was shot into the sump. Inasmuch as, before this occurrence, the engine had worked regularly, it was supposed that the engineman had made a mistake in handling the lever; but when winding was resumed it was found

impossible to control the engine. On the valves being examined, a piece of wooden board as large as the hand was found on the seats of the two admission-valves, which prevented their closing. It is supposed that these pieces of board had been forgotten when new steam-pipes were inserted some time previously, and had been carried along by the steam.

Soon after this accident, the engineman at another shaft noticed an irregularity in the running of his engine during the lift, and, fortunately for the men in the cage, he had the presence of mind to stop the engine without shock. It was found on examination that both of the shaft-guides, for a length of about 130 feet (40 metres) above the place where the descending cage stopped, were much injured on one side by the eccentric safety-catch, and that one of the iron cotters for fastening the eccentrics on their spindles had fallen into the cage, so that, on the latter descending, the safety-catches came into action by their own weight. It is supposed that the cotters had become gradually loosened, and that this circumstance had escaped notice during the usual inspection of the cage before winding was begun; and, for preventing the recurrence of such an accident the author recommends that the cotter be secured by a split pin. J. W. P.

SELF-ACTING INCLINE FOR LARGE OUTPUTS.

Disposition spéciale pour un Plan Incliné à grande Production. By — DE LACHAPELLE. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1898, *pages* 147-150, *and* 4 *plates*.

When the whole of the winding-plant at the Saint-Eloy colliery was transferred from the old Sainte-Barbe shaft to the Puits du Manoir, it was found necessary to drop the coal from the level of the landing in the Sainte-Barbe shaft to that of the new landing, whence arose the necessity for the use of self-acting inclines; and, in order to prevent a large increase in the number of workmen, the inclines were made of as large capacity as possible. The first incline erected, entirely in the seam and approximately following its dip, is 328 feet (100 metres) long; and the gradient, though 20 degrees at the top and bottom, is only 15 degrees in the middle. The line of way, laid with flange-rails, is 41 inches (1·05 metres) between the centre lines of the rails; and, except where the carrying-trucks pass at meetings, there are only three rails, screwed down to the same sleeper.

Two tubs are placed, end to end, instead of side to side, upon the cages or carrying-trucks, an arrangement which has the disadvantage of preventing the possibility of serving an intermediate landing; but, on the other hand, the great advantage of increasing the rapidity of handling the tubs, the two tubs linked together being pushed on, and running off, by one and the same movement; and the sharp gradients at the top and bottom of the incline, facilitate these operations, the latter being automatic.

The catches, set sufficiently apart to receive between them the outside axles of the two tubs end to end, consist of fingers turning in a vertical plane along the centre line of the tub and sufficiently long to hold the axle: the catches, counter-weighted below their axles, assuming a vertical position so soon as the tubs run off or are pushed on.

Since this incline was started, it has, without ever failing, let down on an average 150 tubs per hour, or 1,500 tubs daily, with two men at the top and two men at the bottom in addition to the brakesman. When it was required to send down 180 tubs per hour, an additional man was stationed at the top of the incline. J. W. P.

WIRE-ROPE LUBRICATING MACHINE.

Putz- und Schmierapparat für Förderseile: Patent Oppl. By L. KIRSCHNER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., pages* 609-610, *and* 3 *figures*.

A simple and efficient apparatus for cleaning and lubricating wire-ropes consists of a hollow iron cone-shaped box, divided in the centre horizontally by an iron-plate covered with felt, and having two semi-circular openings. The box is made of two symmetrical halves turning on a hinge, and fitting together when closed. Each half consists of an inner semi-cylindrical lining, through which the wire-rope slips, and an outer part containing the lubricant, and the two communicate through a valve at the bottom of the box. As the rope passes through, the valve opens and allows oil or grease to fall on to it. The apparatus is supported by props on a platform to which it is hooked. The cleaning apparatus is placed above and below the lubricating arrangement. Two sets of semi-circular rubber discs are riveted one below the other to the inner walls of the box, and close round the rope as it is hauled up. Below these are two iron arms, and the three successively scrape the rope, and wipe off the water and slime. Thus cleaned, the rope is greased as it passes through the lubricating-box, and two other projections above remove any excess of oil. All the arms carry small indiarubber brushes with springs, and their distance from the rope is adjustable by screws. As the rope is greased according to the rate at which it is wound, it is best to affix the apparatus when the cage is full of men, and is drawn up slowly. Any kind of lubricant can be used.

It was found that to grease the rope on this system at the Pribram colliery required a much shorter time and much less lubricant than formerly. In one shaft, 40 pounds were used for a length of nearly 3,000 feet of rope, as against 132 pounds before. In another, 77 pounds were used instead of 198 pounds as heretofore, for a rope 7,216 feet long. The apparatus is very simple and easy to work, weighs only 92½ pounds, is easily transported, and the rope is thoroughly cleaned and greased without stopping the winding. B. D.

SUSSMANN ELECTRIC LAMP.

Note sur la Lampe de Mines du Système Sussmann. By AD. ABRASSART. *Revue Universelle des Mines, etc.*, 1898, *vol. xliii., pages* 261-272, *with* 1 *plate*.

The Sussmann secondary battery consists, as is wellknown, of two elements coupled in series, each consisting of one positive and two negative leaden plates contained in an ebonite box, while the electrolyte is a plastic mass consisting of paper pulp soaked in sulphuric acid.

In the British pattern, this battery is contained in a round sheet-iron casing to which a cover is hinged; the glass bulb and its protecting cylinder are bolted to the cover, and the lamp can be pad-locked by means of a hasp. Such a lamp is not permissible in the fiery mines of Belgium, because it does not satisfy the conditions laid down in the report of October 20th, 1894, which stipulates that: (1) Incandescent lamps shall be enclosed in a thick glass globe hermetically closed; and (2) the cases enclosing the generators of the electric current shall be impervious to air or to liquids. The British type, while satisfying fairly well the conditions of clause 1 fails entirely as regards clause 2; hence the pattern used by the Compagnie des Charbonnages Belges has been devised. The battery is introduced through the bottom of the protecting-box, a false bottom being soldered in; this has to be unsoldered when the battery requires repairs or renewals; and the lamp proper with

its reflector is attached firmly to a metal cone, through which connexion is made with the battery. The glass, with a metal cap and the fastening of an ordinary Mueseler lamp, are screwed on to the upper portion of the box, a modified ratchet lock being adopted, held in place by a leaden rivet. This lamp satisfies the conditions of the above report, gives a good light, and is said to be liked by the men. It is, however, heavy, weighing 4⅝ lbs. The author considers this a trivial objection, as the Marsaut type used in the Pas-de-Calais weighs 3½ lbs. Over 200 of these lamps have been in use for a few months in Belgium.

H. L. AND J. W. P.

INSTRUMENTS FOR RECORDING THE SPEED AND WATER-GAUGE OF FANS.

(1) *Appareils enregistreurs des Dépressions et de Vitesse.* By P. PETIT. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1898, *pages* 169-172, *and* 3 *plates*.

The instrument for recording the depression consists essentially of a water-gauge formed by two brass vessels of very unequal sectional area, connected by a pipe fitted with a three-way cock. One vessel, of prismatic form, is connected with a tube leading air from the fan-drift by a pipe which terminates inside it, a little above the level of the water; and in the other vessel, of cylindrical form, a hollow balanced float plunges freely, being suspended by a brass wire from the lever of a Richard recorder on which a diagram is traced. Before the first-named vessel is put in connexion with the mine, water is poured into the other until the level in the two communication-vessels is at least 0·40 inch (1 centimetre) below the end of the pipe; and the length of the brass wire is so regulated that the style shall bear upon the paper band at the highest point (or the lowest in the case of compression). The wire is kept in slight tension; and the movements of the float are reproduced by the style, preferably full-size.

The speed-recorder depends upon the variations of level between two vessels, communicating with one another and filled with the same liquid, the variations being produced by a small turbine whose speed of rotation is proportional to that of the fan or engine to which it is applied.

(2) *Description de divers Types d'Enregistreurs de Vitesse et Dépression.* By — DENOGENT. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1898, *pages* 165-169, *and* 2 *plates*.

The speed-recorder described depends upon the displacement of a disc movable along its axis of rotation, which disc on the one hand is constantly drawn towards a fixed point with a speed proportional to the distance between the disc and the fixed point, and on the other hand has a tendency to be drawn in the contrary direction with a speed proportional to that at which the engine revolves whose speed it is desired to record and control, so that the disc's position of equilibrium is at the exact point of its travel for which the two opposing speeds imparted to it are absolutely equal.

The pressure-recorder consists of a flexible metal box, enclosed in an air-tight metal case, in communication by a small tube with the place in which it is desired to register the variations of pressure. This box is attached to the cover of the outer case, and communicates freely with the atmosphere by means of another small tube, while its flexibility and superficial area are increased by its having a bellows or accordeon form. A rod, attached to the bottom of the box, transmits the variations in the position of this bottom through a series of levers to a style, which traces a diagram on a drum revolving on a vertical axis. J. W. P.

RATIONAL MEASUREMENT OF THE USEFUL WORK OF FANS.

Recherche du Travail utile fourni par les Ventilateurs. By G. HANARTE. *Publications de la Société des Ingénieurs sortis de l'École Provinciale d'Industrie et des Mines du Hainaut,* 1897-98, *vol. vii., pages* 122-147, *with numerous illustrations in text.*

For ascertaining the work done by fans and obtaining a correct idea of the anomalies and differences experienced in the yield of one-and-the same fan under different circumstances, it is necessary to keep in mind the fact that air is a highly compressible fluid whose density is continually changing. In fact, meteorologists know that when the wind strikes the earth in an inclined direction, or when it encounters mountains or clouds, a compression of the air ensues and the barometric pressure rises at the place of impact. What takes place on the earth also occurs in the workings of a mine. Wherever the air encounters an obstacle to its passage, whether in the form of a bend or a restriction, its density, and therefore its pressure, increases for the time, to expand again after passing the obstacle.

As is wellknown, the useful work done by a fan in causing a volume of air, Q, to circulate through a mine is generally expressed by the approximate formula Q h, h being the loss of pressure suffered by the air through friction against the sides of the workings; and this depression, or loss of load, h, is measured by a water-gauge placed at a point in the drift leading to the fan-inlet. If the air's property of recompression be borne in mind it will be concluded that, for measuring the depression, the following precautions must be taken:—

(1) For the water-gauge to indicate correctly the difference of pressure between the outer atmospheric air and the air-current passing through a mine, the end of its tube, bent to a right angle, must be placed in the air-current; and the mouth of this tube, surrounded by a disc, must be placed in a plane parallel with the direction of the current. Without this precaution, the air might strike against the mouth of the tube and become recompressed there, giving false indications, while it might also strike against the vertical portion of the tube, descend it and reach the mouth recompressed.

(2) The air-current, at the place where the pressure is measured, must not have been subjected to a shock that may have temporarily recompressed it, as would be the case near a sharp bend or obstacle.

As may be supposed, by taking into account the compressibility of the fluid, which causes the depression to disappear in proportion to the square of the current's speed, it is almost impossible, except under unusually favourable circumstances, in a long drift leading in a straight line to the fan-inlet, to exactly measure the depression or loss of load undergone by the air, *i.e.*, the factor h of the useful work.

In order to obviate these difficulties and to obtain a practically correct measurement, it is sufficient to run the fan very slowly, to note the volume and the depression indicated by the water-gauge at this slight speed, and to compare the values obtained with the volume and the depression ascertained at the fan's maximum speed. If the water-gauge indicates correctly, the depression at the maximum speed ought to have increased, as compared with that at the slow speed, in the proportion of the square of the volumes, or of the number of revolutions, since the latter are proportional to the volume. Should this not be the case, it may be concluded that the air has undergone a temporary recompression near the water-gauge, and therefore that the indications of this instrument are erroneous.

Let it be supposed, for instance, that a fan running at 40 revolutions per minute causes the gauge to show the depression corresponding with 0·04 inch of

water; then at the speed of 240 revolutions per minute the water-gauge ought to be 1·44 inches, because 40 revolutions : 0·04 inch = 240 revolutions : 1·44 inches. If at this maximum speed, a volume of 60,000 cubic feet, for instance, has been produced per minute, the useful work given out by the fan will be (60,000 × 1·44 × 5·20 =) 449,280 foot-pounds. The volume of air found at the minimum speed of 40 revolutions per minute should also have increased as the square of the number of revolutions; *i.e.*, having been 60,000 cubic feet at 240 revolutions it ought to be 10,000 cubic feet at 40 revolutions per minute. The measurement of these two volumes therefore constitutes one more method of checking.

This easy method, which can be employed by anyone, is based on the invariability of the temperament of a mine, which may in fact be regarded as an air-pipe or passage, and also on the fact that at low speeds the influence of a bend or obstacle upon the recompressibility of the fluid may be regarded as *nil*, which influence increases as rapidly as the square of the volume or of the speed. J. W. P.

EXPLOSIVE MIXTURES OF ILLUMINATING-GAS AND AIR.

Results of Tests made in the Engineering Laboratories. The Technology Quarterly and Proceedings of the Society of Arts, Massachusetts Institute of Technology, 1898, *vol. xi., pages* 187-189, *and* 2 *plates.*

The essential parts of the apparatus used in the experiments were:—A cast-iron cylinder for holding the mixture; a manometer-tube used in making the mixture; a power pump used in clearing the cylinder of the products of explosion; an exhaust-pump for rarefying the air in the cylinder; an indicator; a tuning-fork for obtaining a time-line on an indicator-card; two storage batteries, one wired to the terminals in the cylinder to give the electric spark for the ignition of the mixture, the other being used in connexion with an electro-magnet to keep the tuning-fork in vibration while an indicator-card is being taken; a metallic point attached to the end of one arm of the fork tracing a wave-line upon the card; and an induction-coil.

The following table contains the results of tests of explosive mixtures of illuminating-gas and air:—

Mixture (by parts).	Maximum Pressure.	Time of Explosion.	First One-fifth Second.				One-fifth Second after Maximum Pressure.				
			Area.	Mean Pressure.	Mean Pressure Divided by Proportion of Gas.	Final Pressure.	Area.	Mean Pressure.	Mean Pressure Divided by Proportion of Gas.	* Final Pressure.	Final Pressure Divided by Proportion of Gas.
Gas-air.	Lbs per Sq In.	Secs.	Sq. In.	Lbs. per Sq. In.		Lbs. per Sq. In.	Sq. In.	Lbs. per Sq. In.		Lbs. per Sq. In.	
1-3	45	0·49	0·32	11	44	26	1·30	43	172	40	160
1-4	86	0·08	1·77	59	295	61	1·88	62	310	46	230
1-5	96	0·05	1·86	62	372	52	1·93	64	384	44	264
1-6	88	0·05	1·80	60	420	54	1·93	64	448	46	322
1-7	86	0·06	1·97	66	528	58	1·93	64	512	48	384
1-8	87	0·06	1·71	57	513	53	1·83	61	549	46	414
1-9	77	0·08	1·60	53	530	57	1·86	62	620	46	460
1-10	71	0·11	1·36	45	495	56	1·69	56	616	45	495
1-11	68	0·14	1·21	40	480	60	1·66	55	660	43	516
1-12	39	0·33	0·35	12	156	29	0·98	33	429	30	390
1-13	32	0·42	0·18	6	84	16	0·79	26	364	24	336
1-14	9	0·42	0·05	2	30	4	0·24	8	120	8	120

M. W. B.

THE DETECTION AND ESTIMATION OF CARBON MONOXIDE IN AIR.

(1) *Étude préliminaire d'une Méthode de Dosage de l'Oxyde de Carbone dilué d'Air.* By ARMAND GAUTIER. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol. cxxvi.*, *pages* 931-937.

The author bases his method on the discovery, by Prof. Ditte, that pure carbon monoxide, when heated in presence of iodic anhydride, decomposes the latter, liberates iodine, and itself becomes converted into carbon dioxide. He finds that this reaction commences below 30° Cent., is active at 40° or 45° Cent., and complete at 60° or 65° Cent., no matter to what extent the carbon monoxide is diluted with nitrogen

As 5 molecules of carbon monoxide and 1 molecule of iodic anhydride are concerned invariably in the reaction, and as the volume of the carbon monoxide consumed is equal to that of the carbon dioxide formed, it follows that each cubic centimetre of carbon monoxide corresponds to 0·00227 gramme of iodine liberated; and it is on this basis that the determination of the percentage of the gas in question is effected, the measurement of the gas liberated being checked by titrating the free iodine.

The air to be tested is freed from carbon dioxide, then dried by passage through sulphuric acid, and led through a coil filled with asbestos and iodic anhydride, kept at 65° to 70° Cent. by a water-bath. The effluent gas traverses a tube filled with powdered copper—to retain the iodine—and enters a Müntz tube, where the carbon dioxide is absorbed by potassium carbonate. The gas is afterwards liberated by dilute sulphuric acid, and is measured in a gas apparatus.

Typical analyses made with known mixtures of carbon monoxide and air show that the method gives accurate results up to dilutions of 1 part in 30,000 or even in 3 '0,000 parts of air.

The presence of acetylene, ethylene, and some other hydrocarbons, however, reduces the accuracy of the method, both by themselves undergoing oxidation, and, in the case of ethylene, by retarding the oxidation of the carbon monoxide. On the other hand, methane, ethane, and hydrocarbons of the C_nH_{2n+2} series have no action upon iodic anhydride at the temperature employed in the method, and are therefore without influence on the results.

(2) *Moyen de reconnaître la Présence de l'Oxyde de Carbone dans l'Air confiné.* By F. JEAN. *Annales de Chimie Analytique*, 1898, *vol.* iii., *pages* 260-261.

The potassium permanganate reagent prescribed by Prof. Marmet,* although delicate, is liable to become decolorized not merely by carbon monoxide alone, but also by other reducing substances present in the sample of air. The author consequently prefers to employ a solution of cuprous sulphate, which is not attended with this disadvantage. On causing the sample of air to bubble through a tube filled with this solution, a characteristic red precipitate is formed by the reducing action of carbon monoxide. This method also has the advantage, that it enables comparatively large samples of air to be tested, and hence minute traces of the monoxide can be detected.

(3) *Méthode pour reconnaître et doser l'Oxyde de Carbone en présence des Traces de Gaz Carburés de l'Air.* By ARMAND GAUTIER. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol. cxxvi.*, *pages* 1299-1305.

This gravimetric method is based on the liberation of iodine from iodic anhydride by the action of carbon monoxide, and on the affinity existing between the halogen element and copper.

* *Annales de Chimie Analytique*, 1897, page 163.

The sample of air to be tested is filtered, passed successively through potassium hydroxide and barium-hydrate solution, then dried over phosphoric anhydride and conducted into a tube about 12 inches in length charged with iodic anhydride. The iodine liberated enters an absorption-tube, which, together with the decomposing tube, is heated to between 100° and 105° Cent., and contains a 7 inches stratum of copper reduced, from the state of oxide, in an atmosphere of hydrogen, the latter—which would falsify the test—being eliminated by cooling the copper in an atmosphere of carbon dioxide.

The increase in weight of the absorption-tube during the experiment, multiplied by 0·441, gives the volume of carbon monoxide present in the sample of air, since 0·00441 cubic centimetre of carbon monoxide liberates 0·01 milligramme of iodine.

A source of error is introduced by the presence in the air of the hydrocarbons of the C_nH_{2n} and C_nH_{2n-2} series, these bodies being able to reduce iodic anhydride at temperatures between 65° and 100° Cent., though no action is exerted in this respect by hydrogen or the saturated hydrocarbons. In presence of the first-named gases, the method therefore requires a slight modification, the decomposing and absorption-tubes being dried by a current of air at 220° Cent. and weighed. A phosphoric-anhydride tube is attached to the absorption-tube in order to determine the amount of water evolved, and a set of three tared tubes—containing known weights of phosphoric anhydride, barium hydroxide and phosphoric anhydride in the order named—is also attached. This arrangement enables the amounts of water and carbon dioxide formed during the reaction to be determined, and the oxygen therein estimated. The oxygen given up by the iodic anhydride is estimated by deducting from the final weight of the latter the iodine found in the absorption-tube, the difference between the two weights of oxygen gives the amount referable to the initial carbon monoxide, and, when multiplied by the factor 1·75, furnishes the weight of the latter.

(4) *Sur l'Emploi du Chlorure de Palladium pour la Recherche dans l'Air de très petites Quantités d'Oxyde de Carbone et sur la Transformation de ce Gaz, à la Temperature ordinaire, en Acide Carbonique. By* — POTAIN AND — DROUIN. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, **1898**, *vol. cxxvi., pages* **938-940**.

When allowed to bubble slowly through a dilute solution of palladium chloride, carbon monoxide decomposes and decolorises the liquid. The volume of air containing the carbon monoxide being known, the percentage of the latter can be ascertained by the degree of dilution requisite to reduce another portion of the palladium solution to the same shade as that decolorised.

The apparatus employed by the authors is a long tapered tube connected with the supply of gas under examination, and dipping to the bottom of an outer tube containing the reagent (10 cubic centimetres of a $\frac{1}{10000}$ solution of palladium chloride, and 2 drops of hydrochloric acid). The space between the tubes is closed by an indiarubber ring, and the outer tube being attached to an aspirator the air is drawn slowly through the reagent—which forms a column of liquid about 8 inches in depth—from which palladium is precipitated, in the state of fine powder, by the carbon monoxide present.

No heat is required. One part of carbon monoxide in 10,000 of air can be detected, and in even greater dilution if the volume of the sample be large enough. The air should be freshly sampled, to prevent loss of carbon monoxide by oxidation.

C. S.

LIMITS OF INFLAMMABILITY OF COMBUSTIBLE VAPOURS.

Sur les Limites d'Inflammabilité des Vapeurs combustibles. *By* H. LE CHATELIER AND O. BOUDOUARD. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences,* 1898, *vol. cxxvi., pages* 1510-1513.

In the case of very volatile liquids, *e.g.*, ether, carbon disulphide, benzene, etc., small weighed quantities are shaken up in flasks containing air, and the mixtures are tested until two weights with a difference of not more than 10 per cent. are found, the one inflammable and the other not; the mean of these gives the limit of inflammability within a margin of 5 per cent.

For heavier liquids, the air in the flasks is saturated with the vapour, and the temperature corresponding to the limit of inflammability is determined to within 1°, the amount of vapour present in the mixture at that temperature being ascertained by a separate experiment.

The authors have drawn up the following table of inflammability, the figures in italics being experimental, the others calculated therefrom in conjunction with known data of the heat of combustion and the molecular weight :—

	t.	*p.*	*v.*	*o.*	*q.*
	Degrees.	Grammes.			
Hydrogen	—	—	*10*	5	6·9
Carbon monoxide... ...	—	—	*16*	8	11
Carbon disulphide ...	—	*0·063*	1·94	5·9	4·9
Lighting-gas	—	—	*8·1*	9	10
Petroleum-ether	—	*0·045*	—	—	13
,, spirit	—	*0·051*	—	—	13
Petroleum	*46·5*	*0·057*	—	—	14·5
Methane	—	—	*6*	12	12·9
Pentane	—	*0·034*	1·1	9	9·5
Hexane	—	*0·048*	1·3	12·7	13·1
Heptane	—	*0·047*	1·1	12·3	12·9
Octane	—	*0·049*	1·0	12·6	13·1
Nonane	*12*	*0·045*	0·83	11·6	12 1
Acetylene	—	—	*2·8*	7	8·9
Amylene	—	*0·046*	1·6	11·9	12·8
Benzene	—	*0·044*	1·5	11	11·6
Toluene	—	*0·049*	1·3	11·4	11·8
Terebenthene	*30·5*	0·042	0·73	10·2	10·9
Naphthalene	*69*	—	—	—	--
Acetone	—	*0·073*	2·9	11·6	12·7
Methyl alcohol	*8*	0·081	6	9	10·8
Ethyl ,, ...	*13·5*	0·060	3·07	9·2	10·3
Propyl ,, ...	*25*	0·065	2·55	11·5	12·5
Isopropyl ,, ...	*17*	0·068	2·65	12	12·7
Isobutyl ,, . .	*27·5*	0·053	1·68	10·1	10 8
Allyl ,, ...	*25*	0·074	3·04	12·5	13·4
Amyl ,, ...	*38*	0·045	1·19	9·0	9·5
Acetic acid	*36*	0·103	4·05	8·1	8·9
Ether	—	*0·060*	1·9	11·7	12·5
Ethyl acetate	—	*0·087*	2·3	11·7	12·3
,, nitrate	—	*0·145*	3·8	—	12·2

In these columns, t is the temperature of saturation; p, the weight of water per litre of mixture at 15° Cent.; v, the percentage volume of vapour in the mixture; o, the volume of oxygen required for complete combustion; and q, the amount of heat evolved by the combustion of 1 molecular volume of the mixture, *i.e.*, 23½ litres, at 15° Cent.

C. S.

LIMITS OF INFLAMMABILITY OF CARBON MONOXIDE.

Sur les Limites d'Inflammabilité de l'Oxyde de Carbone. By H. LE CHATELIER AND O. BOUDOUARD. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1898, *vol.* *cxxvi.*, *pages* 1344-1347.

Though the heat generated by the combustion of carbon monoxide gas is great, it opposes a certain unanticipated resistance to oxygen, as is evident from the slow propagation of the flame and the high limit of inflammability. This condition was investigated by the authors who, working with a tube 10 inches (25 centimetres) long and 1·57 inches (4 centimetres) wide, found the range of inflammability to lie between 74·5 and 15·9 per cent. On reducing the width of the tube to below 0·091 inch (2·3 millimetres) the mixture could not be ignited, whatever the proportion; and other tests showed the direct influence of the diameter on the result: 16·1 per cent. of carbon monoxide giving an inflammable mixture in a 0·54 inch (13·8 millimetres) tube, whilst 61·7 per cent. was required to produce ignition in a 0·26 inch (6·6 millimetres) tube. The influence of barometric pressure is also considerable, the tendency to ignite disappearing when the pressure recedes below 3·15 inches (80 millimetres) of mercury, whereas 15 per cent. of lighting gas is inflammable even at 2·52 inches (64 millimetres) of pressure.

An endeavour was made to ascertain whether in mixtures of carbon monoxide and acetylene the formula applicable to the limits of inflammability in mixtures of two gases of similar composition, holds good. An affirmative result was obtained. On the other hand, mixtures of carbon monoxide and hydrogen do not follow this rule, the deviation being about 4 per cent., *i.e.* beyond the limits of experimental error. C. S.

COLLIERY EXPLOSIONS IN PRUSSIA DURING 1897.

Mittheilungen über einige der bemerkenswerthesten Explosionen beim Preussischen Steinkohlenbergbau im Jahre 1897. ANON. *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate*, 1898, *vol. xlvi.*, *pages* 237-246, *and* 1 *plate*.

Upper Silesia.—The Explosion at the Hedwigswunsch Pit on April 1st, 1897.—Here three seams of highly bituminous coal had been worked for about 18 months, and no signs of spontaneous combustion were detected, so long as operations were confined to the west of a fault which cuts off a triangular area in the south-western portion of the property. When, however, some headings had been driven east of the fault in the Heinitz seam, breaking through to the "old man" in the Reden seam, against which the first-named is faulted, an evolution of fire-damp was observable in the Reden seam for the first time on March 25th. The dangerous area was closed off by timber dams, and the further extension of the workings was limited to the westward of the fault. Six days later, on March 31st, a great deal of inflammable gas came off along the edge of the "old man" in the Heinitz seam east of the fault and in the Reden seam west of it. By reversing the ventilation, and setting a fresh ventilator to work at the August shaft, the dangerous gases were led off without passing through the workings. More timber dams were put up to shut off the area of conflagration, and nothing of any consequence took place till ½ hour after midnight (March 31st to April 1st), when a noise resembling the fall of rock was heard in the "old man," and blue flames burst out through No. 8 dam. The people there had begun to spray the dam with water when suddenly an explosion took place, followed at very short

intervals by two others, destroying nine dams. Two miners sustained slight burns, while others merely had their hair singed. In the forenoon of April 1st, the dams were built up again, and the normal course of the ventilation was re-established. About 3 p.m., a fresh explosion took place, destroying 5 dams, and killing 6 persons who had gone down the pit to procure samples of the gas for analysis. The ill-fated party consisted of the manager of the mine, a viewer and an underviewer, two analysts, and a laboratory assistant. The efforts of rescue-parties to reach the victims were rendered nugatory by the continual outpour of poisonous gases. It was not until 8 p.m., when the 5 dams had been put up again, that the bodies were recovered. As a smell of burning became more and more perceptible even in the rear of the rescuers, showing that gases were still oozing through the dams into the workings, it was considered prudent to withdraw the rescue-party and suspend any minute examination of the site of the disaster. The actual cause of the ignition of the gases has not been ascertained. Possibly it may be traced to the naked lights carried by the victims of the accident.

Further damming operations were being carried on, but with masonry, when on the morning of April 5th still another explosion occurred, in the Heinitz seam. The workmen fled for their lives, and, fortunately, nothing more disastrous happened than the overthrow of some of the dams, whereby all control of the ventilation was lost for the time being. Finally, the whole area of conflagration in the three seams was walled off by two masonry-dams, and the Holz shaft was closed down. By the end of February, 1898, it was found possible to re-enter this area; the dams are being pushed farther and farther in, and it is expected that before long the last remnants of the fire will be extinguished.

Dortmund District.—1. *Coal-dust Explosion in the Pluto Pit, March 17th,* 1897. —This took place at the sixth level (1,767 feet below bank) in No. 5 south seam, which belongs to the upper bituminous coal group. This seam gives off very little gas, but makes a considerable amount of dust when worked. Shot-firing with guhr-dynamite, blasting-gelatine and gelatine-dynamite is allowed by the regulations, only on the condition that safety-cartridges are used. Moreover, continual abundant watering of the coal-dust is prescribed. But it appears that the last-mentioned precaution had been pretermitted at the very spot whence the explosion subsequently started. Two dynamite-cartridges were fired, to help in clearing out an area obstructed by fallen coal and timbering, and this evidently caused the accumulated coal-dust to explode with fatal results, 8 men being killed. The formation of coke-crusts was comparatively slight, and no wreckage of timbering, etc., is recorded. In view of this disaster, the Royal Mining Bureau at Dortmund issued the following order :—"All persons whose duty it is to fire shots are bound to look to it that the blasting-cartridge is provided with proper stemming. It is forbidden in all collieries to fire shots unprovided with stemming, or to ignite loose blasting-cartridges which are not enclosed in a bore-hole."

2. *Fire-damp Explosion in Shaft II. of the Count Bismarck Pit, March 23rd,* 1897.—Nine men suffered more or less serious injury as a consequence of this explosion, which reads a striking lesson on the foolhardiness of which miners are too often guilty in dangerously fiery workings. The seam belongs to the gas-coal group, has an average thickness of 2½ feet, breaks into cubical masses, and shows very little tendency to dust-formation. There is not, on the whole, much evolution of gas observable; but when at times it is found necessary, in making up the height of the galleries, to bring down the clay-shale which forms the roof, considerably more gas comes off: this is less noticeable in the case of the floor.

During 5 days the inspector of ventilation had noticed, in the haulage-road belonging to that portion of the workings which became subsequently the starting-point of the explosion, daily increasing accumulations of fire-damp. On the day preceding the accident, there was a volume of explosive gases extending over a length of 22 feet or more, and over the entire height of roof (39 inches) which had been taken out for the haulage-road. The working-face itself was clear of gas, and more or less temporary ventilation was afforded by lifting now and then the brattice-cloth which closed the gallery. Working was continued uninterruptedly, and, in disobedience to all the regulations, no report was made to the manager. On the day of the accident still more gas was found coming off, and the under-viewer (in the absence of the viewer through illness) warned the miners and emphatically forbade any shot-firing. They paid no heed to this order, and continued drilling shot-holes in the presence of the subordinates who brought them the message. The result was such as might have been predicted: the gases, which were being drawn outward by the ventilating-current past the working-face, were ignited either by the sparks proceeding from a guttapercha fuze or by the flame from a lamp which was afterwards found lying unlocked near a coal-tub. Under the circumstances, the author considers the former alternative the most probable. The victims of the accident suffered very serious burns, from which four of them subsequently died. In the workings themselves no destructive effects were visible, nor does there appear to have been ignition of coal-dust.

As a consequence of this disaster, the Royal Mining Bureau issued on August 10th, 1897, more stringent regulations for the working of seam C. Shot-firing was to be undertaken only under the direct supervision of officials specially deputed for that purpose. Locked safety-lamps, safety-igniters, and safety-explosives were alone to be used; and for each man employed below ground at least 105 cubic feet of air must be the ventilation-allowance.

3. *Fire-damp Explosion at the Oberhausen Pit on April 14th*, 1897.—This took place a few moments before the day-shift started work in the bituminous Carl coal-seam (30 inches thick), in a district of the mine where all shot-firing was forbidden by Government order. Improvements in the ventilation-system were being carried out at the time, and a vertical shaft was sunk which passed through an unworkable seam that gave off a considerable amount of gas; this was got rid of by temporary makeshifts. In this shaft 3 men were at work; they, with 7 others, were the victims of the explosion. Some died from burns, and others from suffocation by after-damp. Coal-dust played a very small part in the explosion, which evidently started in the above-mentioned shaft, and must have been due to some carelessness in the handling of the lamps, as the men had no materials with them for shot-firing.

4. *Fire-damp Explosion at the Westphalia-Verein Pit, Kaiserstuhl II. Shaft, on December 22nd*, 1897.—This was the most considerable of any accident that took place in the Dortmund district in the course of the year. It occurred in seam No. 12 during the afternoon shift, between 4 and 5 p.m., and of the 23 persons employed in that portion of the mine 20 were killed and the others severely injured. Seam No. 12 is regarded as the least dangerous of the generally fiery group to which it belongs, and the average proportion of marsh gas present in this abundantly-ventilated pit was only 0·33 per cent. The coal is very dusty, and the regulations consequently prescribe the systematic watering of working-places and roads. On account of the great pressure of the strata in the area where the explosion occurred, permission was given, however, to dispense with watering there, on the following conditions:—Shot-firing to be prohibited; safety-lamps with double wire-gauze alone to be used; and the number of workpeople to be restricted to 20. Through

some misunderstanding spraying was stopped in another part also. The exact sequence of events in the disaster has not been ascertained. Crusts of coke were found in many working-places, but not on the inclined haulage-planes, although here dust lay about in enormous quantity. In proportion to the amount of coal-dust noted as present in the mine after the explosion, the amount actually ignited was very small. Great falls of rock took place, and ventilation-doors and brattices were half-burnt or otherwise damaged. After-damp interfered considerably with the rescue-operations, and if portable breathing-apparatus, such as oxygen-inhalers, etc., had been at hand, there is no doubt whatever that many of those lives that were lost would have been saved.

Neither the cause nor the starting-point of the explosion are certainly known, but it is proved that there was no shot-firing, no surreptitious opening of lamps; and it seems probable that the gases struck through to the flame of a single-gauze safety-lamp, which had been accidentally brought in with the double-gauze lamps.

L. L. B.

THE EXPLOSION AT THE SZÉCHEN PIT, DOMÁN, HUNGARY.

Grubenunglück im Széchen-Schachte zu Domán in Ungarn am 24. Jänner, 1898. By L. LITSCHAUER. *Berg- und Hüttenmännisches Jahrbuch der k.k. Bergakademien zu Leoben und Přibram und der königlich Ungarischen Bergakademie zu Schemnitz,* 1898, *vol. xlvi., pages* 257-274, *and* 1 *plate.*

In view of the disastrous experiences of the last few years, the Resicza-Domán collieries of the Austrian State Railway Company must be classed in the category of dangerous mines. In 1894 there was a fire-damp explosion in the Almásy pit of the Domán colliery; this was followed, on December 18th, 1896, by a most disastrous explosion in the neighbouring Széchen pit, about ½ mile away; and at 10 p.m., on January 24th, 1898, another explosion occurred in the same pit, whereby 10 persons lost their lives. This catastrophe only escaped being as overwhelming as the former one, because the highly explosive pit-gas, charged with excessively fine coal-dust, did not ignite as in the previous case.

The scene of the explosion was No. 6 level, 1,300 feet below bank. Here the uppermost of the two seams worked is 13 feet thick, and dips 50 degrees southward. The lower seam at this horizon is split into two portions, known as "roof bench" and "floor bench," one being 195 feet above the other. It appears certain that these benches are merely portions, faulted asunder, of one and the same seam, and the coal hereabouts betrays signs of great disturbance. In estimating the causes of the recent disaster, the existence of accumulations of gas at high pressure must be noted in connexion with the cracks, fissures, and hollows frequent in these disturbed strata.

The coal in the Széchen pit, and still more so in the Almásy pit, is extremely friable—so friable that it can hardly ever be brought out of the workings in big lumps. As might be expected under such circumstances, enormous quantities of very fine coal-dust are constantly formed in the mine, and water-spraying was prescribed many years ago by the authorities. In the Almásy pit, watering-cans have up till recently been used for this purpose in the dustier workings, but, as the dust forms with extraordinary rapidity, this method must be regarded as inadequate. A new watering-system is now being laid down, in which the Széchen pit-waters are made use of, no other water-supply being available for the purpose.

The Almásy pit is ventilated by a Pelzer fan 8 feet in diameter, and the Széchen pit by a Guibal fan 29¼ feet in diameter, 6½ feet wide, and with a maximum

capacity of 36,000 cubic feet per minute. The course of the ventilation is such that the air-current passing out of No. 6 level after the explosion brought the fire-damp even into the upper workings which lay in the path of the air-current, and thence to the surface. The circumstance that, in addition to the main current, the Széchen pit is also ventilated by an auxiliary current coming from the Almásy pit, diminished in no inconsiderable degree the fearful violence of the explosion, and, besides facilitating the escape of the miners, rendered the task that lay before the rescue-parties less arduous. No. 6 level is in communication with the Franz Josef gallery 822 feet above it; and here steam-haulage has been replaced by electric haulage, on account of the danger of ignition of the pit-gases and coal-dust by sparks from the locomotive. Nevertheless, the steam-engine is still used whenever the electric apparatus gets out of order; and it happened very fortunately on the day of the accident that the locomotive had been removed from the mine ¾ hour before the explosion took place. Until quite recently, the Franz Josef gallery has been used as an airway to take the foul air out of the pit, besides being a haulage-road; but great improvements are being made in the ventilation-system of all the pits in the district.

The average quantum of air per minute per man passing through the Széchen workings at the time of the disaster was 176·5 cubic feet, or 35 cubic feet more than the amount prescribed by the regulations; while in the Almásy pit the corresponding amount was 229·5 cubic feet. In this respect 1 horse is reckoned to require as much air as 4 men.

Turning from ventilation to lighting, the safety-lamps used in these collieries are of the Wolf benzine type, with double gauzes and magnetic locks: they are very strictly checked, carefully cleaned, and kept in good repair. As a proof of the perfect control kept over the lamps, it is sufficient to mention that scarcely one of those picked up in the pit after the disaster was found to be in the least damaged. Three only, found near the immediate starting-point of the explosion, were in an abnormal condition, being choked up with coal-dust, which appeared to have been forced through the meshes of the wire-gauze by the enormous air-pressure.

The night shift on January 24th numbered 141 men and boys, 15 of whom were at work in No. 6 level. The evidence given by the 6 survivors out of these 15 shows that a series of violent detonations were accompanied and followed by great rushes of gas mixed with coal-dust, which knocked some of the men down and deprived them of consciousness. All the deaths appear to have been due to suffocation, and very few traces of external injury were found on the bodies.

The violence of the explosion may be gauged from the following details:—The western gallery of No. 6 level was choked up for a length of 52 feet with coal which had been hurled along and mostly ground to powder, and the whole gallery itself fell in. In the upper airway, coal-dust was blown right into the eastern district, a distance of 367 feet. The volume of gas set free must have been enormous, when one bears in mind also that the return-air at the exit of the Franz Josef gallery was still highly explosive ½ hour after the disaster, while the ventilator was working at forced speed (2·6 inches depression).

As a consequence of the 1896 disaster, very special precautions had been taken in this pit, and only minute quantities of fire-damp were ever noticed. But now and then various miners would tell the officials that they often heard a report —louder at some times than at others—proceeding from that portion of the workings where the outburst afterwards started. The investigations conducted by a committee, a few days after the disaster, showed that the gases had torn an opening in the coal about 11 feet square and 10 feet long. L. L. B.

EXPLOSIONS IN COAL-MINES, AND THE CONSEQUENCES OF AN EXCESSIVE ARTIFICIAL VENTILATION.

Les Explosions dans les Mines de Houille et les Conséquences d'un Excès d'Aérage artificiel. By FRANZ BÜTTGENBACH. *Revue Universelle des Mines, etc.*, 1898, *vol. xliv*, *pages* 262 to 266.

Dr. Haldane's report upon the experiments made in consequence of the explosions at Tylerstown colliery, at Brancepeth colliery, on April 2 th, 1896, and at Micklefield colliery on April 30th, 1896, permit a comparison with the accident which happened in February, 1898, at Carolinenglück colliery, Westphalia, where 120 workmen were killed, most of them suffocated at a distance of more than 3,000 feet from the place of the explosion, and at a much higher level, about 650 feet, in the mine. Dr. Haldane's report, addressed to the Home Secretary, stated that a mixture of 1·8 per cent. of carbon monoxide in air caused faintness, with loss of consciousness in 8 to 10 minutes, and followed by death in 30 or 40 minutes to human beings, owing to the absorption of carbon monoxide by the blood.

At Brancepeth and Micklefield collieries, it is stated that 80 per cent. of the victims were suffocated by carbon monoxide.

Explorations did not prove that the explosions were caused by fire-damp, which in this case might have ignited the coal-dust, but experiments made upon the inflammability of coal-dust suspended in air suggest the opinion that in this case, as in almost all those in which we can establish the combustion of dusts, the presence of fire-damp had caused their ignition.

In the explosion at Carolinenglück colliery, we may ask how an explosion which occurred at a depth of 1,600 feet could cause the death of workmen occupied in the mine at such distances from the site of the explosion. If the energy of the explosion be the cause, we should find damage throughout the gallery in which it occurred, timber reduced to splinters, and the victims mutilated. On the contrary, injuries were found only upon a small number of the bodies lying in the vicinity where the explosion originated. The timber of the galleries was found covered with a material having the appearance of coke, and due to the distillation of the coal-dust. It is impossible that all the workings and galleries of the mine should have been filled with coal-dust in suspension sufficiently dense to carry the fire to distances of thousands of feet. There can be no doubt that artificial ventilation has carried throughout the mine with a rapidity proportional to the energy of the ventilators, air charged, it may be, with 20 per cent. of carbon monoxide, and this gas is the cause of the suffocation of the workmen employed at distances of 3,000 feet, and in galleries situated about 650 feet above the level of the explosion. As these injurious effects are produced within an interval of not more than 10 minutes, the explosion, having broken and destroyed the doors erected in the galleries to direct the ventilation, the atmosphere charged with carbon monoxide almost immediately reaches the most distant galleries, it may be diluted to 1·8 per cent. which is sufficient, according to Dr. Haldane, to knock down a man in 8 minutes, and to suffocate him in 30 or 40 minutes.

There can be no doubt that the gaseous products of the explosion, and especially the carbon monoxide which is formed by the combustion of coal-dust suspended in the working-places, by expanding rapidly throughout the mine produce these injurious effects. Owing to these facts, one must ask whether a point has not been reached in the volume of artificial ventilation which cannot be exceeded except with great danger. Atmospheric air can be charged with 15

to 20 per cent. of fire-damp without becoming irrespirable, but 1·8 per cent. of carbon monoxide will suffocate a man in a few minutes.

An energetic ventilation is certainly an efficacious means of diluting fire-damp and making it harmless; but experience unfortunately proves that the most energetic ventilation will not prevent explosions. Explosions generally destroy the ventilating-doors and the galleries between different levels. The current of air must then take another route than that assigned to it, and the suffocating gases are quickly diffused throughout the whole of the mine. The more energetic the ventilation the sooner the gases produced by an explosion will spread and produce the injurious effects which occurred at Brancepeth, Micklefield and Carolinenglück collieries. The question should therefore be asked: at what point should one limit the volume of ventilation?

Mr. G. Köhler, director of the School of Mines at Clausthal, in a paper upon the explosion at Carolinenglück,* proposes to make arrangements by which, irrespective of cost, oxygen may be distributed into all the workings after an explosion. The writer thinks that this project presents almost unsurmountable difficulties. Although it will be useful to have oxygen at one's disposal in all coal-mines to be used in cases of suffocation, he thinks that it will be difficult to diffuse this oxygen in a gaseous state into the workings in a mine within a period of less than 10 to 30 minutes after an explosion. Mr. Köhler remarks that an energetic ventilation is the best means of removing dust, but experience proves that the upper portions of galleries are scarcely reached by the most energetic ventilation. An excess of air has, however, another consequence: the coal-dust is very rapidly dried, and this is especially the case where the dust is resting upon timbers in the upper portion of the galleries. We find heaped-up accumulations of dust, many inches in thickness, resisting the most energetic ventilation, and it does not contain any moisture. An explosion is required to set the dusts in motion, and if the ignition produces enough carbon monoxide to make a mixture containing 1·8 per cent., an energetic ventilation will comprize the whole mine in a catastrophe, which would otherwise have remained within reasonable limits. Energetic ventilation is therefore an imminent danger, or at least an augmentation of the danger.

The water-spraying of galleries as well as of all the places where dust may be produced is a good method of preventing, or at least of diminishing, the effects produced by the sudden combustion of coal-dust, but the watering of dust deposited upon timbers, etc., requires a very costly plant, which few mines can adopt. Moreover, the operation of water-spraying should be continuous, as an energetic ventilation quickly removes the moisture communicated to the quiescent coal-dust.

M. W. B.

NEUPERT RESCUE APPARATUS.

Ueber Athmungsapparate beim Bergbaubetriebe und speciell über den Rettungsapparat der Firma O. Neupert's Nachfolger in Wien. By JOHANN MAYER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1898, *vol.* xlvi., *pages* 1-4, 17-22, *and* 34-38, *with* 1 *plate.*

The author states that the Walcher-Gärtner pneumatophore† has the disadvantage that, being carried in front of the wearer, it tends to encumber his arms, particularly when stooping, and also prevents him from carrying a rescued miner or other weight in the easiest position. Moreover, there being

* *Berg- und Hüttenmännische Zeitung*, 1898, vol. lvii., page 88.

† *Trans. Inst. M.E.*, vol. xiv., page 575.

no mask, but only a nose-clip and mouth-piece—both liable to get out of place while in use—the apparatus cannot be regarded as perfect, more especially since there is no valve to prevent re-inhalation of unabsorbed carbon dioxide, to say nothing of the defective absorption of this gas by caustic soda and the inconvenience arising from the necessity of shaking the air-bag now and then to secure better distribution of the liquid.

In order to remove some of these objections, the Neupert apparatus has been constructed from the author's instructions.

The new appliance consists of an indiarubber or leather air-bag, in the shape of a short shoulder-cape, surmounted by a helmet of similar material, with a glass mask fitting over the face. The helmet is loose, but the edges of the mask fit tightly against the face, communication between the latter and the air-bag being effected by a couple of valved tubes, one for inhaling, and the other for the expired air. The air bag only extends about 6 inches below the wearer's chin, and hence does not incommode or restrict his movements.

Air is supplied to the bag by a pipe leading from a bottle of compressed oxygen —the capacity being about 5,400 cubic inches (90 cubic centimetres) and the pressure 100 atmospheres—which is supported at the wearer's side or back by a bandolier, and can be removed and replaced in 5 seconds. The supply is adjusted by suitable check- and reducing-valves.

The air-bag is charged with some solid, such as stick caustic potash or soda, or granulated soda-lime, capable of absorbing carbon dioxide, these being found preferable to liquid absorbents, inasmuch as they at the same time dry the air and do not raise the temperature within the mask. In experiments made by the author it was found that in two instances, after 2 hours' wear, this temperature was 25° and 31° Cent., whilst that of the absorbent solid potash itself was 38° and 57° Cent. respectively, thus showing that most of the heat developed by the chemical action of the materials is retained by the absorbent and not radiated.

Experiments made to ascertain the most suitable absorbent show that there are several factors influencing a decision, the most important being the physical character, relative effective weight, and rapidity of action—this latter tending to reduce the temperature and consequently the perspiration. Thus, quick- and slaked-lime, though the best absorbents, must be discarded because the lumps tend to fall to pieces and become powder Again, whilst caustic soda is relatively lighter than potash—the proportion being as 80 : 112—and is also cheaper, it nevertheless is less suitable, by reason of its less energetic and rapid absorptive faculty.

For example, when 7 ounces (200 grammes) of water—*i.e.*, about the quantity liberated in the apparatus, from the breath of an average man, from the formation of potassium carbonate, and by perspiration during 2 hours—were placed in contact with 17½ ounces (500 grammes) of caustic potash in a jacketted vessel which was tested for rise of temperature, the figures obtained were 85°, 95°, 74° Cent. at the end of 2, 10 and 90 minutes. In the case of caustic soda, the temperatures recorded at the corresponding periods were 48°, 80° and 61° Cent.; hence caustic potash exhibits a greater degree of energy in action.

To determine the charge required, it is known that a man engaged in active work requires 1·4 ounces (39·8 grammes) of oxygen per hour and exhales 1·9 ounces (53·5 grammes) of carbon dioxide in the same time. On this basis, a charge of 4·8 ounces (136 grammes) of caustic potash would be necessary; but in order to leave a sufficient margin for contingencies 17½ ounces (½ kilogramme) of potash are employed for 2 hours' work, the oxygen supply also being arranged at threefold the theoretical requirement.

UNDERGROUND PUMPING ENGINES.

Les Machines d'Épuisement souterraines. By P. HABETS. *Bulletin de l'Association des Ingénieurs sortis de l'École de Liége.* 1898, *vol. xxii., pages* 203-218.

The author passes in review underground pumps driven directly by a steam-engine, those put in motion by hydraulic transmission of power, and those actuated by electrical transmission, arriving at the following conclusions:—The three methods of driving are of about equal value as regards steam-consumption; but in this respect those with transmission of power are more economical when, with a view to future eventualities, the pumping-engine has been put down of greater power than that ordinarily required. In such a case the pump is not worked continuously; and, if it be driven directly by a steam-engine, the consumption will increase in inverse proportion to the number of hours that it works daily. In many cases the advantages of lower consumption and the suppression of underground steam-pipes compensate for the higher first cost of pumps driven by power transmitted from the surface.

Hydraulic transmission of power has the advantage of great simplicity as regards both the plant and its maintenance. The pressure-pumps run slowly with a long stroke, and may be provided with very perfect valve-gear, so that the steam-consumption may be reduced below 16½ lbs. (7·5 kilogrammes) of steam per horsepower in water raised; and, with hydraulic pumps not consuming more than 14 lbs. (6·5 kilogrammes) of steam per indicated horsepower, the consumption of pumps driven by hydraulic transmission will be less than 22 lbs. (10 kilogrammes) per horsepower in water raised.

Electricity requires high-speed motors—or those of moderate speed (100 to 125 revolutions per minute) if the generating dynamo be driven directly—engines with short stroke that are often less perfect as regards their steam-distribution; but otherwise the dynamo must be driven by belt or rope, which is not so favourable as regards the general useful effect. The management of electric plant appears more difficult than that of hydraulic pumps; but the transmission of electric current by cables is more economical than that of water under pressure in pipes; and cables are more easily laid than rigid pipes. It follows, therefore, that electric transmission is better suited for long distances, while lending itself more readily to driving appliances of various kinds. The conditions of each case will, moreover, determine the nature of transmission to be employed; and, according as it may be required to drive only one pump, or various machines, preference will be given to water or electricity. J. W. P.

PREPARATION PLANT AT THE SAINT-ÉLOY COLLIERIES.

Houillères de Saint-Eloy (Compagnie des Forges de Châtillon, Commentry et Neuves-Maisons): Note sur la Préparation mécanique. By — DE MORGUES. *Bulletin de la Société de l'Industrie Minérale*, 1897, *vol. xi., pages* 745-756, *and* 4 *plates*.

The Saint-Éloy coal, long-flame, non-bituminous and containing from 36 to 40 per cent. of volatile matter, is non-pyritous and leaves an almost infusible white ash, so that it only yields a light and porous coke; but, apart from its industrial applications, this coal is excellent for household use.

When a new winding-shaft was started it became necessary, in order to meet trade requirements, to take measures for permitting of at any time varying the sizes of the coals, of sending them off dry, or of passing on to the washing-plant the whole or part of the various sizes made, and also of mixing them—in any proportion required—by mechanical means.

The mouth of the shaft is connected with the upper floor of the screening-plant by an iron bridge provided with endless-chain haulage, the fingers of which catch the tubs by their axles and take them up to the tippler-floor, that has an area of 4,300 square feet (400 square metres), sufficient to store 1½ hours' production, and thus affords means for regulating the out-turn of the screens however the output of the shaft may vary. Indeed, the whole of the storing bins permits of stocking nearly a day's output, which was one of the principal objects aimed at in designing this plant. The 4 side tipplers, worked off the general shafting, are thrown into gear by a hand-lever, while the stoppage is automatic.

In order to avoid a choking of the No. 3 Coxe screens, the coal is first passed over an inclined grate with bars 6 inches apart, a roller 2 feet in diameter, which makes 4 revolutions per minute, being placed below the tippler-hopper for regulating the feed of coal. The various qualities of coal are separated underground, so that each screen serves for one quality only, except the third which generally requires two screens; but, in the event of break-down, screening can be continued while one screen is out of use.

As the proportion of lump coal with adherent shale is considerable, namely, 5·3 per cent. of the whole output or 14·7 per cent. of the lump coal and cobbles, a special department has been arranged for its treatment, the pickers breaking the pieces and removing the rock.

The cobbles and pea-coal fall on to one set of carrying-belts and the slack on to others, moving at the rate of 2 feet and 2¼ feet respectively per second, there being three belts for each size, while slides, worked from the floor, permit of sending the products of a screen to any one of these three belts, which are reversible and pass over six large storage-bins each holding 80 tons; and the slides, placed over each belt and above each hopper, ensure the delivery as may be desired of the coal from each of the belts on to that of the storage-bin required. This triple combination permits of directing to any given bin the coal of each of the four screens and of each size, so that any size may be washed separately, or any mixture made that may be called for.

The four lines of way, two for the lump coal and two for the cobbles, pea-coal and slack, are connected, by a traverser, with the siding from the Saint-Éloy station; and a series of switches and turntables permits of turning all the loaded waggons on to a single line of way. Below all the points where coal is discharged are spouts movable in three directions, while they can be raised or lowered, lengthened or shortened; and they are also capable of a lateral displacement equal to the width of a waggon, in which, therefore, the load can be distributed very regularly.

The whole screening and washing-plant is driven by a 75 horsepower engine making 32 revolutions per minute; and the exhaust steam may be sent at will into the condenser, into the open air, or into a warming pipe extending throughout these departments. J. W. P.

KREISS OSCILLATING CONVEYER.

Transporteur à Canal oscillant, Système Kreiss. By C. LEVET. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1898, *pages* 159-160, *and* 1 *plate.*

This conveyer consists simply of a sheet-iron channel mounted on inclined timbers forming springs, and receiving a rapid reciprocating motion. The very principle of such a motion, even if of slight amplitude, would appear to exclude the use of this form of conveyer for transport to any considerable distance; but the difficulty has been surmounted by thoroughly balancing the moments of inertia in the following manner:—

The conveyer is divided longitudinally into an even number of equal lengths or sections; and a single crank-shaft drives two consecutive lengths in inverse directions (this for each group of two lengths), which completely annihilates the momentum, that cannot be transmitted to the framework supporting the channel. Motion is transmitted by rope from one shaft to another; and each length of channel may be 130 feet (40 metres) long, so that the distance between two consecutive crank-shafts is 260 feet (80 metres). A conveyer so arranged, 575 feet (176 metres) long, mounted on supports 13 feet (4 metres) high, has been put up for stacking coal; and slides, arranged every 6½ feet (2 metres), permit of delivery at any point in the length of the conveyer. J. W. P.

LOADING OR STACKING PATENT FUEL BY AN AIR-LINE.

Transport aérien des Mines du Plat-de-Gier. By — CASTELLAN. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1898, *pages* 111-114, *and* 1 *plate*.

As the site of the screening-plant and briquette-fuel works affords no room for stacking on the spot, land was bought on the other side of a public road, and 8 feet (2·5 metres) higher than the screening-floor level. The products of two briquetting presses, about 10 tons per hour, are conveyed by a travelling-belt of double that capacity for either direct loading on to waggons, or stacking and again taking from stock.

A travelling-belt, 151 feet (46 metres) long when extended, and 2 feet (60 centimetres) wide, driven directly by the press, receives the products of the latter, and conveys them either directly to waggons or, if for stacking, to a second carrying-belt, the upper or forward part of which serves for delivering them on the stack, and the lower or following part, that passes through an underground passage, for taking from stock, in which latter case a bucket-chain raises and loads them into waggons.

When the briquettes have to be loaded directly, instead of being stacked, an oblique rake causes them to fall through one of several spouts into a waggon; but when, on the contrary, they have to be stacked, they fall from the end of the first belt on to the second, 1¼ feet (40 centimetres) wide, and the extended length of which is 722 feet (220 metres), that is made to travel at the rate of 3¼ feet (1 metre) per second by means of a small steam-engine.

At the point where it is desired to make the briquettes leave the belt, there is an oblique rake with wooden roller for raising the belt a little, so as to permit the briquettes to pass from the belt on to a lateral channel for preventing breakage at the commencement of the heap; and this channel is formed of sections, having various lengths, reaching almost down to the ground at the commencement of stacking. Each section is removed as the height of the heap increases; and when the top of the heap reaches nearly up to the belt, the drum carrying it is shifted from time to time so as to give the heap an elongated form. In this manner, a heap of 380,000 cubic feet (10,725 cubic metres) is formed, equal to a weight of about 8,260 tons.

For taking out of stock, one or more of the slides that cover openings about every 6½ feet (2 metres) in the roof of the underground passage are withdrawn, when the ovoid briquettes fall directly on to the lower or following end of the belt which draws them along until an oblique rake obliges them to fall into a hopper, whence a bucket-chain raises them to the waggon. In this manner 20 tons may be taken from stock per hour. J. W. P.

SALLAC COAL-TIPPLER.

Vertheilungs-Wipper. By Ot. Novák. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1897, *vol. xlv., pages* 361-362, *with illustrations.*

A new tippler has lately been introduced by Mr. Sallac, which, although it has an equal speed during a whole revolution, does not run empty at all, but delivers continuously on to the screen. The discharge of the coal is independent of the time of emptying. The tippler has two tyres, each provided with a pair of U-irons and stop-forks. They run upon four rollers, and the back tyre is connected to a toothed wheel with a rack gearing into a friction-pulley. The tippler is thrown on and off automatically by a lever. The frame is made to receive a truckload of coal at a time, and the bottom is specially shaped to prevent the coal from sticking as it is tipped down the shoot on to the screen. The tippler carries from 6 to 8 shovels affixed to it at different points, which, as it gradually turns over, successively help to push down the coal. The last shovel checks the coal in its descent, and deposits it gently in the shoot, thus avoiding breakage. When the full tub has been pushed on to the tippler, it is set in motion by a lever, and the shovel at the bottom begins to rake the coal still remaining from the last load, about half a tubful, down the shoot. As the tippler turns, the other shovels are brought round one by one, and act upon the coal. By the time the full waggon is tipped over and emptied, all the coal left in the shoot has passed on to the screen. The shovels push down the fresh coal till about half has descended, and the tippler, having completed a revolution, is seized by the forks, and brought to a stand. Thus the screen is fed uninterruptedly, and the tippler never runs empty. When the tubs are changed there is a pause of 2 to 5 seconds, but as at this point the shovels are closer together and send more coal on to the screen, the tippler still continues to deliver without intermission. By accelerating its speed of revolution, four waggons per minute may be emptied without difficulty.

A test was made at a mine in Austria with this rack-and-clutch gear attached to an ordinary tippler, and gave excellent results. A new tippler was started in November, 1896, and has already tipped more than 200,000 tubs so successfully that it has been found possible to reduce the length of the screen by one-third. The shovels do not break up the coal, and the shoot is never clogged, even when pieces of large coal (23 inches) are passed through it.

Complete drawings of the apparatus are given in the original paper.

B. D.

HUMBOLDT COAL-WASHERS AT THE BLANZY COLLIERY.

Note sur les Lavoirs Humboldt en montage aux Lavoirs pour Agglomérés. By — Graillot. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale,* 1898, *pages* 204-211, *and* 1 *plate.*

Owing to the constantly increasing output of the Blanzy colliery, the washing-plant, twice increased, still proved insufficient. Accordingly, the order was given for the erection of two Humboldt plants, each capable of washing 800 tons in 10 hours, and the first of these is on the point of completion.

A large bucket-chain raises the coal of 0 to 2·37 inches (60 millimetres) gauge to a large hopper at the top of the building, whence it falls into a Humboldt trommel, or sizing-drum, fitted with spirals, where it is separated, dry, into three sizes, namely, from 2·37 inches to 1·77 inches (60 to 45 millimetres), from 1·77 inches to 1 inch (45 to 25 millimetres), and from 1 inch to 0·39 inch (25 to 10 milli-

metres). The coal does not remain in the trommel during more than a single revolution, only one size, that from 1·77 inches to 2·37 inches (45 to 60 millimetres), turning backwards after the first revolution and making its way out on the following, so that the pieces are not broken by the screening. Under this first trommel is a line of five washers each receiving a size of coal, slack from 0 to 0·39 inch (10 millimetres) gauge being alone received in a channel with a stream of water, which carries it along to the second trommel with spirals to be separated, wet, into three sizes, from 0 to 0·12 inch (3 millimetres), from 0·12 inch to 0·28 inch (3 to 7 millimetres), and from 0·28 inch to 0·39 inch (7 to 10 millimetres), each of which sizes is passed on to one of five piston-washers.

This washing plant is noteworthy on account of the first summary classification and also the re-washing of all the "shales" produced during the first part of the operation, as well as the suppression of *schlamm*, sludge or coal-dust mud, which is incorporated with the fine coal in the following manner:—Near the hopper for receiving the washed fine coal there is a large chamber, into which the water falls from the hopper in a cascade; and this chamber, sufficiently large for the speed of the water to be almost *nil*, has below it eight hopper-shaped boxes wherein the mud settles, while the opening of cocks in which the boxes terminate allows the muddy water to pass, on its way to a storage-chamber. This water is delivered into the channel of the washed slack, which is carried along by it to the storing towers; and, on a tower becoming full of coal, the sluice-valve through which coal and water enter is closed, and the water in the tower drains through the wire-mesh terminating its point. The wash water, forming a complete circuit, is put in motion by centrifugal pumps and a pulsometer; and it is estimated that the quantity to be renewed per minute is only 55 gallons (2½ hectolitres), which may be furnished at will by that draining from the pea-coal, by the overflow of the condensation-water or by the warm water of condensation. J. W. P.

WUNDERLICH COAL-WASHER.

Stromwäsche: Patent Wunderlich. By V. WALTL. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1897, *vol. xlv., pages* 357-358, *with* 2 *figures.*

The Wunderlich system of washing coal has for some years been adopted with the best results in several of the principal mines in Bohemia. There are two types of the apparatus. In the first, the shale and rubbish fall through openings in the purifier, and are raised by an elevator to a second washer where they are separated, the rubbish being carried off, and the shale passing on to an endless belt. The two washers are similar in construction, but the second serves two or three purifiers. The advantage of the double process is that the coal does not require previous sorting, and low-grade coal can be dealt with in any quantity.

In the second type, the design is the same, but the two washers are combined. The water is raised by a centrifugal pump to the trough, in the bottom of which are separate openings for the rubbish and shale, and a divided space below to receive them as they fall. The rubbish is then carried off by a small elevator, while the shale passes to a belt, where the water is drained from it, and the clean coal is conveyed along another belt worked by an endless chain, to a hopper. One washing suffices to separate the coal from the impurities, but it must be previously sorted to a certain extent, and only a given quantity can be treated at a time.

Both kinds of washers may be used singly or coupled. In a double washer, the water is raised by a centrifugal pump, and sent on to two troughs, each of

which is fed separately with coal. There is one elevator and draining-belt for the rubbish and shale, and a single transmission-shaft, while two belts carry off the coal. These duplicate washers are compact, only about 18 inches wide, yield a large output of good coal, and require little power. A Wunderlich coal-washer has been in use at two of the principal mines in Austria for $2\frac{1}{2}$ years, and 200,000 tons of coal have been treated. The best results are obtained with high-grade coal carefully sorted, while low-grade unpicked coal is not so suitable. The output varies with the size of the coal. With coal in pieces from 1 to 2 inches, the maximum output is 550 pounds per minute per washer; with coal $\frac{1}{2}$ to $\frac{1}{4}$ inch it is 330 pounds per minute, the latter being the approximate mean output for all sizes. The centrifugal pump delivers 740 gallons of water per minute. The yield from these washers is about 80 per cent. of pure coal, 3 per cent. of grits, 7 per cent. of shale, and 10 per cent. of waste and rubbish. Coal of medium size, from 1 to $1\frac{1}{2}$ inches gives the best results. The cost of washing is about 10d. per ton, and two men are required to work the washers. The original paper is illustrated by a drawing. B. D.

PURIFICATION OF COAL WASH-WATER AND ARTIFICIAL FORMATION OF SHALE.

L'Épuration des Eaux de Lavage. By — BONNOTTE. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale,* 1898, *pages* 157-158, *and* 1 *plate.*

After the water used for coal-washing has passed through three hopper-shaped boxes, in which it leaves the greater part of its mud, it flows into a precipitation-tank, where it becomes completely freed from argillaceous slime, and is pumped up, only a little thick, for use over again in the washers; but the tank must be cleared of slime every two days, while, notwithstanding the auxiliary precipitation-tanks, the effluent fouls the channel leading to the canal, so as to cause complaint from the canal-management.

The idea was then conceived of pumping up the muddy water of the tank (this being necessary on account of the relative levels) so as to filter through a large heap where the refuse from coal-working and the boiler-ashes are tipped; and, during the seven months that this natural filter has been in operation, the water has flowed off from the tip in a sufficiently limpid state, while the complaints have ceased.

About 20,000 gallons (900 hectolitres) of muddy water are poured over the tip during the day of 10 hours; but this quantity is more than necessary, because the water of the precipitation-tank is renewed three times in that period. Small walls are made with boiler-furnace clinker at a suitable place on the tip, in such a manner as to form two separate basins into which the muddy water is delivered alternately. When one is choked up, the mud is thrown over the side of the tip, while the other basin is used as a filter. In this manner, a very good water for coal-washing is obtained; and the muddy water flows over the tip, which is on fire.

At the same time, shales more or less carbonaceous are formed artificially; and, by introducing sand into the stream of water, all Coal-measure rocks have been reproduced. The shales are found to be stratified with lines changing their direction, so as to represent sections of natural shale; and drying goes on so rapidly in the open air that in a few days a shale of remarkable hardness and compactness is obtained. J. W. P.

DETERMINATION OF CARBON IN IRON AND STEEL.

Zur gasvolumetrischen Bestimmung des Kohlenstoffes in Eisen und Stahl. By ED. DONATH AND W. EHRENHOFER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv.*, *pages* 284-286, *with* 3 *figures.*

The amount of carbon in iron and steel is generally determined by analysis, and the method used should be accurate, simple and rapid. The Eggertz process of making the determination according to the colour of the iron is useful, but it has the disadvantage of being dependent, not on fixed quantities, as weight or volume, but upon the eye of the observer, and it is not of general application. To estimate the quantity of carbon in iron from its weight is a complicated and lengthy process, and the suggestion was made by Prof. Wiborgh to determine it by measuring the gaseous volume of carbon in the carbon dioxide. This method has been applied for 6 years at the Technical Chemical Laboratory at Brünn, in Moravia, and its accuracy has been checked by analysis by weight. The Wiborgh apparatus is, however, too small, and the absorption of the carbon dioxide with caustic potash takes place in the measuring-tube itself. The process has been modified by introducing the gas into a Hempel sampling-apparatus, and eliminating the volume of carbon dioxide by absorption with caustic potash in a separate pipette. Further improvements, especially in simplicity, have been made by Dr. von Reis. The simpler the instrument, the better for the chemist of a foundry, who has often to analyse and determine the percentage of carbon in about six charges of steel daily. As at present constructed, the Wiborgh-Reis apparatus has advantages which ought, in the opinion of the writer, to make it more generally adopted by metallurgical chemists, who still look with distrust upon this method of analysis.

It consists of a small bulb with narrow neck, a measuring-tube or burette, and an absorption-bottle. Communication is made between the three vessels by a three-way cock. The burette has a volume of 170 cubic centimetres and a scale graduated to 0·10 cubic centimetre. It is surrounded by an outer tube filled with water and carrying a thermometer. The neck of the bulb is closed with a tight glass joint, made in one with the tube of a filter above. The quantity of iron tested varies from 4 grammes for 0·3 per cent. of carbon to 0·2 gramme for 3½ per cent. of carbon. To each ½ gramme of iron 5 cubic centimetres of a saturated solution of blue vitriol is added, the mixture being well stirred, and the carbon separated. By raising the levelling-bottle and manipulating the cock, the carbon dioxide is passed over into the burette; communication is then made with the absorption-bottle, which is partly filled with caustic potash. To every 0·001 gramme of carbon about 0·1 gramme of solid chromic acid is allowed. The carbon dioxide is sampled under a mixture of 20 parts of water to 100 parts of concentrated sulphurous acid, and absorption proceeds in the same way as in the Orsat apparatus. From two to three determinations are required so that all the carbon dioxide may be absorbed. The apparatus is easy to manage, and the caustic potash does not often require renewal. As the same water is used over and over again, it becomes saturated with carbon dioxide, and ceases to absorb it. Mercury is sometimes used for making the joint, but is not so convenient as water. Drawings of the instrument are given in the paper. B. D.

DETERMINATION OF PHOSPHORUS IN IRON AND STEEL.

Die Phosphorbestimmung in Stahl und Eisen. By LEOPOLD SCHNEIDER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., pages* 326-328, *and* 344-347.

It is usual to determine the presence of phosphorus in iron and steel by the molybdenum process. A solution is first made of nitric acid, the strength of which must be carefully chosen, in order that it may dissolve all the phosphorus, although the latter is never completely oxidized to phosphoric acid. Experiments made by the writer on both iron and copper containing phosphorus confirm this view, in spite of some chemists who maintain the contrary. Solutions of three different strengths of nitric acid were used; 0·10 gramme of phosphate of copper was mixed with each, boiled for 10 minutes, and after cooling, 100 cubic centimetres of molybdic acid was added to it and left to stand 24 hours. The deposit was then filtered, weighed, and treated with permanganate of potash, when it yielded a phosphorus precipitate varying in quantity according to the solution used. Thus the addition of some chemical, preferably manganate of potash, is necessary to reduce all the phosphorus in iron to phosphoric acid.

To precipitate the latter, about 4 times its amount of molybdic acid and one-eighth the quantity of nitrate of ammonia are added, and the process is hastened by heating and frequently stirring the mixture. A table in the original paper gives the relative proportions of the three chemicals, which should be carefully determined, to ensure complete precipitation. About 5·5 per cent. of molybdic acid and from 7 to 30 per cent. of nitric acid are the right quantities; the proportion of nitrate of ammonia does not greatly affect the results. Precipitation should, if possible, take place at ordinary temperatures. The precipitate thus obtained is filtered and washed with nitric acid, nitrate of ammonia and pure water. It is then dissolved in ammonia in a porcelain crucible, steamed, acidulated with a little weak nitric acid, and heated for ½ hour over a gas-burner. The chemical formula of the deposit is 12 $MoO_3,PO_4,(NH_3)_3$.

To determine the chemical composition of the precipitate rapidly, the proportion of molybdic acid is ascertained by titration, and the percentage of phosphorus calculated from it. This is, however, a difficult operation. The writer proved that molybdic acid can be completely reduced to molybdic sesquioxide, but the latter is easily oxidized afresh by contact with the air. In his experiments, titration with manganate of potash, however carefully carried out at different temperatures, always yielded less of the chemical constituents than the formula. The differences depended on the quantity of molybdenum, and the rapidity of the process. If the molybdic acid be reduced under hydrogen gas, and the proper amount of manganate of potash be added from an air-tight bulb, the right quantities will be obtained, but if air penetrates during titration the oxide in the acid combines with the oxygen in the air, and affects the results. If hydrochloric acid be used, the air must be excluded in the same way.

Some writers maintain that soluble glass saturated with nitric acid and treated with ammoniated molybdic acid shows the same reactions as fluids containing traces of phosphoric acids. The writer proved by experiment that this is not the case, and that if such reactions take place they are due to the presence of a minute quantity of phosphorus. Under certain conditions, arsenic acid combined with solutions of molybdic acid yields a finely-powdered yellow precipitate. This was tested by mixing it with the three solutions of molybdic acid of different strengths

already used. After 24 hours at an average temperature none of the three showed any precipitate, but from one of the solutions a yellow deposit was obtained after heating. However small the proportion of arsenic, a part of it appears to be always precipitated with the phosphorus. B. D.

UTILIZING THE WASTE HEAT OF COKE-OVENS.

Note sur l'Utilisation de la Chaleur produite par l'Atelier de Carbonisation des Mines de Ferfay. By — SOULARY. *Bulletin de la Société de l'Industrie Minérale,* 1898, *vol. xii., pages* 343-379, *with 3 figures, 2 diagrams, and 3 plates.*

The plant consists of (*a*) 16 Bernard ovens, firing two water-tube boilers at a pressure of 78 pounds per square inch (5·5 kilogrammes per square centimetre); (*b*) 16 Coppée ovens, firing two semitubular boilers at a pressure of 114 pounds per square inch (8 kilogrammes per square centimetre), the steam being expanded, however, to the above-named pressure; and (*c*) 20 Coppée ovens, firing three water-tube boilers, larger than those of group *a*, and generating steam at the lower pressure abovenamed. The boilers of groups *b* and *c* are alone employed in normal working, the heating-surface utilized being about 6,000 square feet (555 square metres) over which are distributed the gases yielded by 145 tons of coal, containing 28 per cent. of volatile matter, charged per 24 hours; the heat given out by the gases being nearly 1,924,560 British thermal units. The author observes that the determination of the weight of gas required for vaporizing a weight-unit of water constitutes a method which has the advantage of permitting comparison between boilers whose heating-surfaces may be of quite different kinds. In this manner he found that for evaporating 1 pound (or 1 kilogramme) of water 0·313 pound (or 0·313 kilogramme) of gas was required with the water-tube boilers of group *a*, 0·246 for the semi-tubular boilers of group *b*, and 0·164 for the large water-tube boilers of group *c*. He therefore considers that this group is the most economical, while it affords the following advantages. It permits the use of muddy or chemically impure feed-water. By substituting for the flues a few vertical baffle-plates, it offers no resistance to the passage of the gases utilized, while facilitating the examination of the boiler. By the large dimensions given to the combustion-chamber, it permits of placing the boiler in a hot place, where the gases have no appreciable speed and thus the plates are not subjected to burning, even during sudden and rapid disengagements of gas. Owing to the combustion-chambers, the gases are completely burnt, and the chimney never smokes; and it may be supposed that the gases are thoroughly utilized, since the yield of the plant is equal to that of the best boilers. The difference between the maximum and minimum vaporization is less than that with other forms of boilers, thanks to the large mass of water, which acts as a regulator; and, as the charges of coal and the hours of charging are approximately constant, this regulator, instead of creating a danger that might be feared with coal-fired boilers, affords, on the contrary, a guarantee of security that is wanting in multitubular boilers subject to sudden variations of pressure.

The author concludes that a well-designed water-tube boiler gives as high a useful effect as one of multitubular type, without possessing its many disadvantages, and that it also affords a greater measure of safety. J. W. P.

DRYING FIRE-CLAY.

Ueber das Trocknen von Thon in grösseren Massen und einen neuen Thontrockenofen By F. TOLDT. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1897, *vol. xlv., pages* 387-391, *with figures in text and* 1 *plate.*

The methods in use for drying fire-clay depend on the purpose for which it is intended. If it is to be freed from moisture by indirect heat, and not baked in a kiln, the hot air or gases must be raised to a high temperature. As the fire-clay is chiefly used as cement, care must, however, be taken that it is not dried till it ceases to be adhesive, and a good circulation of air should be kept up. The higher the temperature of air, the more water will it absorb. Thus, saturated air at 212° Fahr. (100° Cent.) will contain nearly 35 times as much water as at 68° Fahr. (20° Cent.), and air with 60 per cent. of moisture will contain relatively about the same proportion of water.

To dry fire-clay thoroughly, it must be brought into close contact with air circulating at a high temperature, therefore the roof of the drying-chamber should be low, and the floor heated, so that the water in the clay may be evaporated by the vertical ascending currents of hot air. If the temperature of the latter be high, a smaller quantity will be required, and all the heat in it will be utilized to evaporate the moisture. At an air-temperature of 212° Fahr. (100° Cent.), about 30 per cent. fewer heat-units are required to dry the fire-clay than at 68° Fahr. (20° Cent.). The fire-clay should also be kept moving in an opposite direction to the hot air.

The ordinary drying-kilns are made large enough to admit a man, and are filled and emptied by hand. This arrangement involves much labour, the furnace must be periodically put out, to re-charge it, and only a small quantity of fire-clay can be dried at a time. The writer has therefore designed a new furnace to dry the fire-clay used for making pots for crucible steel, and in it these difficulties are avoided. The roof of the drying-chamber is low, the furnace occupies little space, is fed mechanically and continuously, and the hot air is admitted in the contrary direction to the moving clay. The type followed is that of the Moser furnace, with an inclined floor, for roasting ore. The fire-clay passes through the drying-space in one direction, the hot air rises to meet it, and the lumps of clay are turned over in their passage. The drying-chamber has an inclined surface, and is about 15 inches high. The clay breaks a little as it dries, but, as it must be remoulded, this does not signify. At the side of the furnace is a space into which the dried fire-clay falls, and where it is stored dry, ready for use. An economy of heat results from working the furnace continuously, and never allowing it to cool.

No difficulty has been experienced from the clay sticking and becoming clogged in its passage. If the angle of inclination be suitably chosen, it ought, although damp, to slide down easily. This angle was determined after repeated experiments, and is always near the angle of repose of the clay. An angle of 32 degrees was originally chosen, and as soon as the iron plate was a little worn, the clay slid easily over it. So long as the furnace is properly supplied with fire-clay, there is no fear of the inclined drying-plate becoming clogged. To make the clay turn over in its passage, the inclined surface is broken by a step half way down, and the angle for this step has also been carefully determined.

In the original paper, the writer gives three drawings of different types of his drying-furnace. In the first, to economize space, the upper half of the inclined plane on which the clay rests slopes in one direction, the lower half in the opposite. The lumps of fire-clay turn as they fall from one to the other, but it is

rather difficult to heat the plates. At the bottom of the furnace is a horizontal grate for small coal, and the combustion-gases are carried under the plates and heat them, before passing through several coils on their way to the flue. Air is introduced above the grate, and after being thoroughly heated, rises through a passage, and circulates over the clay. To prevent overheating, a large quantity of this cold air can be admitted below the plates, according to the indications of a maximum thermometer connected with an electric bell. The clay is introduced at the top of the inclined plane, and slips easily down; the lower half of the plate rests upon iron arches. This arrangement is compact but costly, as so much iron is used in its construction. In a larger but less expensive type, there is only one inclined plane at two levels, with a step between. The air for heating is admitted above the furnace by a small fan, and passes through a kind of regenerator before reaching the fire-clay. The drying-space has valves above and below for admitting and discharging the clay. The lower part of the inclined plane rests on fire-brick, and the flames play directly upon the upper part. In a third type, the clay is not turned as it slides down, but falls into a vertical shaft at the side of the furnace, which is heated by the hot air.

To dry 10 waggon-loads of fire-clay in 4 weeks, a drying-surface of about 1,000 square feet was required with the old system. With the new furnaces, the same quantity can be treated with a drying-surface of about 400 square feet. The quantity of air required for drying at different temperatures may be calculated. Formerly from 2 to 4 cwt. of fire-clay were dried per hour. Taking these as a basis, 4 cwts. or 448 lbs. of dry fire-clay corresponds to 539 lbs. of damp clay, or 18·4 per cent. of water, and 91 lbs. of water per hour must be evaporated. As the power of absorption of air is proportioned to its temperature, which determines its volume, it is only necessary to know the former in order to calculate the number of cubic feet which should be admitted per hour to dry a given quantity of fire-clay, containing a given percentage of moisture. B. D.

PYROMETERS.

(1) *Die Bestimmung des Brennwerthes von Kohlen mittels des Mahler'schen Calorimeters und nach Jüptners empirischer Formel.* By HANS FREIH. V. JÜPTNER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., pages* 457-460.

The Mahler calorimetric bomb for determining rapidly and accurately the heating value of coal is wellknown. These determinations are usually checked by the Dulong formula calculated from the chemical analysis of the coal, namely: $8080\,C + 34462\,(H - \frac{1}{8}\,O) + 2250\,S$, and the two generally agree. Prof. von Jüptner proposes another method for obtaining the same results simply and rapidly, and with close approximation to the calorimetric data. The proportions of moisture W, of volatile matter G, of fixed carbon K, and of ash are determined in a crucible, and the total quantity of oxygen required, S, by the Berthier test. The quantity of oxygen required for the combustion of the carbon is $S_1 = \frac{8}{3}\,K$; for the combustion of the gaseous distilled products $S_2 = S - S_1 = S - \frac{8}{3}\,K$. The ratio of the oxygen required for the volatile products to that needed for the combustion of the carbon is $S_2 + S_1 = (S - \frac{8}{3}\,K) \div \frac{8}{3}\,K = (\frac{3}{8}\,S - K) + K$. The heat of combustion of carbon is taken at 8,000 Cent., while the (variable) heat of combustion of the oxygen required to burn the gaseous products we will call C. Thus the heating value of the combustible will be $p = 80\,K + C\,(S_2 + 100)$. The heat of combustion of the

sulphur is taken at 2,500° Cent. In the original paper, the values of C for hard coal with values of $S_2 \div S_1$ varying from 0·2 to 8·0 are given in a table. The heating values of fifty kinds of American coal are calculated according to this formula, and differ slightly from the calorimetric results, but agree sufficiently for practical purposes. The method has also the advantage of determining the heating-value of the gases which escape during the dry distillation of the coal, and the calorimetric value of the latter can thus be more easily determined. B. D.

(2) *Pyromètre Actinométrique.* *By* — BONNEL. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1898, *pages* 145-147.

It is wellknown that if two thermometers, one with its bulb blackened, be exposed to the same source of luminous heat under the same conditions, that with the blackened bulb will rise higher than the other; and the difference will be so much the greater as the temperature is higher.

The Latarche actinometric pyrometer consists essentially of a bent thermometer, of which the blackened bulb and horizontal arm are fixed in a tube terminating on the furnace-side in a diaphragm, which allows a pencil of luminous heat-rays to impinge on the pyrometer, passing through an aperture in the furnace-wall in such a manner as not to intercept the radiation. The apparent (visible) vertical arm is graduated; but the absolute temperature of the thermometer may vary, while it is the difference of temperature that must be measured. The tube passes through a cast-iron box filled with water, brought to boiling-point by the heat of the furnace, the temperature of which is measured by the difference between the temperature shown by the thermometer and the boiling-point of water. J. W. P.

APPLICATION OF OXYGEN IN THE CYANIDE PROCESS.

By H. T. DURANT. *Journal of the Chemical and Metallurgical Society of South Africa*, 1898, *vol. i.*, *pages* 59-62, *with* 1 *illustration.*

In the cyanide treatment of concentrates, tailings or slimes, the necessary oxygen must be either:—(1) dissolved in working-solutions, or (2) applied during treatment.

The working-solution may be aerated by blowing air into it from a compressor or blower, allowing the air to be delivered near the bottom of the sump, through a pipe perforated with small holes, of which the sum of the areas should approximate to the area of the cross-section of the pipe conveying the air. Another method of aerating working solutions is circulation by means of a centrifugal pump. Such a pump always draws, at the glands and joints, more or less air, which in its passage through the pump must attain a very fine state of division; hence the air presents a very large surface, and, being under increased pressure in the delivery-pipe, all conditions are favourable for its solution. Apart from leakages, which are variable, the author by a special air-valve supplies air to the suction-pipe of the centrifugal pump.

The diagram, given in the above-mentioned journal, illustrates a centrifugal pump, sucking from the bottom of a vat and delivering into the same vat. Between the pump and the vat is a Peet valve; between this valve and the pump are one or more small air-valves, opening inwards only, and closing whenever the internal pressure equals or exceeds the external pressure.

Now, assume the pump to be working, close the Peet valve slightly, the supply of liquid becomes less than the capacity of the pump. If the small air-valve is

now slightly opened, air will be continuously drawn into the suction-pipe, and will undergo ideal contact with the solution during its passage through the pump. The quantity of air drawn in will be, within certain limits, proportional to the closing of the Peet valve. It is essential that the lift of the pump should be as small as possible and free from unnecessary bends, etc., or more power is required and greater speed on the pump. The pump being flooded, the air drawn through the air-valves can never stop the pump from working ; the air-valves being only slightly opened, the pump does not get as much air as it could take, hence there is no alternate opening and closing of these valves. They are constantly open.

The author then describes the advantages of double treatment and of dry leaching. In treating slimes, current-slimes (*i.e.*, those direct from the battery without intermediate storage) contain comparatively little organic matter or oxygen-absorbing substances, and hence present fewer difficulties in treatment than is the case with accumulated slimes. Mr. W. A. Caldecott was the first to aerate accumulated slimes by means of compressed air. Results are quoted showing the advantage of aeration by a centrifugal pump (as described above) in the treatment of old slimes from various sources. J. W.

ECONOMIC TREATMENT OF SLIMES.

By CHARLES BUTTERS. *Journal of the Chemical and Metallurgical Society of South Africa*, 1898, *vol. i.*, *pages* 5-10.

For the past 3 years, the author had been specially engaged on the problem of recovering gold from the slimes produced by battery-crushing, and, at a recent meeting of the Chamber of Mines of the South African Republic, the President (Mr. Geo. Rouliot) stated that the treatment of slimes was now an economic success at Johannesburg.

It was observed that if slimes were allowed to be deposited in dams for a comparatively short time, even for a few days, decomposition of the pyrites took place, and thus it was found much more economical to treat slimes directly as received from the mill. Now, the slimes in battery-water are coagulated by means of lime, concentrated by spitzkasten and then settled in collecting-vats. These settled slimes, containing about 50 per cent. of water, are now ready for treatment, and another great advantage is gained by the separation of the slimes from the plate-water, as the latter can at once be returned to the mill for re-use.

In slimes, a substance was found which could not be leached, or through which the solution would not percolate: it was, therefore, found necessary to wash by decantation. A combined process of decantation and leaching by means of vacuum-pumps was tried by the Rand Central Ore-reduction Company, at their Robinson slimes-works. Such a process for rich slimes, running 15 dwts. or more to the ton, is well adapted to give a high extraction ; but, for the treatment of low-grade slimes as produced on the Rand, this combined process was too expensive.

The process adopted by Mr. J. R. Williams, at the Crown Reef slimes-plant, known as "natural settlement," and afterwards adopted at the Robinson works, is now the method generally used. The principle of oxidation of the reducing substances in slimes by means of aeration was put into practical use by Mr. W. A. Caldecott, who, in a paper read before this society, has given the reasons that render this operation specially necessary in the treatment of accumulated, or acid, slimes.

In concluding, the author thinks that the main features of this new metallurgical process will be practically retained, wherever adopted in other parts of the world. The use of lime for settlement, the use of spitzkasten for collecting-tanks for natural settlement, dissolving the gold by means of agitators or centrifugal pumps, the decantation of the liquid, and a precipitation by an electrolytic method are, he thinks, permanent features, which in detail may be modified to some extent, but which will remain with us. J. W.

REDUCTION OF ZINC-GOLD SLIMES.

By E. H. JOHNSON. *South African Mining Journal, June 26th*, 1897, *with* 2 *figures*.

This paper describes the method used by the author at the Princess cyanide works, Roodepoort. Not having a filter-press, he converted one of the two 6 feet diameter clean-up vats into a filter-vat, by putting in a grating, having holes 1 inch square, covered with fine, closely-woven canvas.

The sheet of 2 drawings shows sections of the filter and acid vats. Through the side of the vat below the filter-bed, a $1\frac{1}{4}$ inches pipe is led, connected with a small suction-pump bolted to the side of the vat. From the delivery of the pump, a light movable launder leads the filtered solution back to the top of the precipitation-boxes. The zinc-gold slimes (including such small zinc as may have passed the grating of the zinc-boxes) are bucketted direct into the filter-vat, and as soon as one box is cleaned-up and the washed zinc replaced, the pump is started and the solution returned by means of the launder back into the box. The pump is kept going gently, after the boxes are completely cleaned-up, until only the slimes are left on the filter. A water-wash is then pumped through till the slimes are free from cyanide. The gross weight of the slimes, including moisture, is then determined, as they are transferred in buckets to a large sheet-iron tray near the acid-tank. The object of weighing is to find the amount of sulphuric acid necessary to destroy the zinc. The second of the two clean-up vats is fitted with a wooden stirring-apparatus and cover, the parts being made detachable so as to be moved easily when action has ceased. A 3 inches pipe leads the irritating fumes outside the building. Having found the approximate weight of slimes to be treated, sufficient water is run into the acid-vat to form, on addition of the acid, a 10 per cent. solution. The author found that 1 pound of acid to every pound of moist slime gave good results. Having the requisite amount of water in the vat, the weighed quantity of acid is then added and the vat is closed down tightly. The stirring is kept going continually, as the slimes are gradually fed in, and should be continued for $\frac{1}{2}$ hour after the action has, apparently, ceased. The feed-hopper has a sheet iron slide-door, in addition to the closely-fitting cover on the top; thus the slimes can be charged without permitting any appreciable escape of fumes, within the building. After charging the slimes, the hopper and everything used in the clean-up are rinsed by a jet of water. The stirring-apparatus is then removed and well washed in the vat during removal. The vat is then filled with water and allowed to settle. Without heating, a perfect settlement was obtained in 1 hour. When heating by a steam-jet, settlement was much more difficult. The clear liquor is siphoned off, and the vat filled repeatedly with water, until the solution is neutral to litmus paper. The resultant gold-slime is dried, on an open drying-hearth, in large cast-

iron enamelled dishes; then the cakes are broken up, and subjected to an increased heat, in thin layers on small sheet-iron trays. When cool, the slimes are ground, fluxed, and transferred to the crucible, yielding 50 to 60 per cent. of their weight as bullion. The average fineness of the bullion over the year was 820. The cost of reduction, including acid, was 6·7d. per fine ounce. The advantages of this method are:—Elimination of the zinc without recourse to calcination—the loss from which is so difficult to determine; the handling, except in the final operation, is of wet slime and secures consequent immunity from dusting; and the time from commencing to clean-up to having the bar in the safe need not exceed 3 to 3½ days. The slag assayed (after panning out prills) only 23 ounces per ton. J. W.

SILVER REDUCTION-WORKS IN MEXICO.

The Reduction-works for Silver-ores at Aduana, Sonora, Mexico. By MILTIADES TH. ARMAS. *Journal of the Franklin Institute*, 1898, *vol. cxlvi., pages* 293-302 *and* 349-357.

The ores treated here are complex, containing grey copper, blende, galena, copper-glance, arsenical and antimonial sulphides, etc., all argentiferous, the gangue being mostly quartz. The ores are treated by smelting, for which ores carrying mainly copper with some galena and blende and 350 to 600 ounces to the ton are selected; by milling, for ores in which zinc blende predominates, containing 48 to 72 ounces of silver; by concentration when the silver is below 27 ounces to the ton; and by lixiviation, for ores carrying 60 to 400 ounces to the ton.

The ore for lixiviation is crushed dry in a ten-stamp mill of 813 lbs. stamps through a 16 meshes screen. The washed ore is roasted in reverberatory furnaces of the ordinary type measuring 14 feet by 9 feet, with fan-stepped hearths, the total time of roasting of a 1,200 lbs. charge being from 8 to 12 hours; salt to the amount of 4 to 8 per cent. is added in the last hearth. The chlorination averages 97·5 per cent. There are nine vats 20 feet in diameter and 5 feet high, and the entire plant can treat 37 to 47 tons. The ore is first leached with water which dissolves base metals (copper) and a little silver, and then with a solution of hyposulphites of calcium and sodium. The cost of chlorination and lixiviation is $17·87 per ton. The best strength of leaching-solution is found to be between 0·55 and 0·60 per cent. The silver is precipitated by calcium polysulphide. The accumulated sulphides of silver are collected twice a week, filtered off, calcined at a very low heat, and then mixed with litharge, producing argentiferous lead for cupellation.

The solution of base metals is run over the mattes produced in smelting, by which means the mattes are enriched from 35 to 40 per cent. of copper, and also reduces all the silver contained in the solution.

The concentrating ore is wet-crushed in a ten-stamp mill, and the pulp is sized and concentrated on frue-vanners and buddles; this operation costs $1·52 per ton. The concentrates are made into bricks with clay, roasted in stalls, and smelted with the complex smelting-ores in a water-jacket furnace 39 inches in diameter, of 40 tons capacity, with 6 tuyeres: the blast-pressure being 1½ inches, and the volume about 1,400 cubic feet of air per minute. Iron-ore and limestone are the fluxes used, but in as small an amount as possible in order to produce together with base bullion a matte rich enough to export and a slag with only 1·3 ounces of silver to the ton.

The cupellation is conducted on an English cupel, made of decomposed rhyolite and limestone in the proportion of 46 : 100; the cupel 46 by 59 inches in area

requires 1,579 lbs of the mixture; its capacity is 3,500 lbs. of bullion. It lasts 40 days, the loss of silver is 0·7 per cent., and the average fineness of the silver produced is 990.

In 1896, the cost of an ounce of fine silver was as follows:—

	Dols.		Per Cent.
Cost in mining	0·391	or	36·0
,, milling	0·286	,,	26·4
,, administrative expenses	0·075	,,	6·9
Profit	0·333	,,	30·7
Totals	1·085	,,	100·0

H. L.

UTILIZATION OF TIN-PLATE REFUSE AND CUTTINGS.

Verwerthung von Weissblechabfällen im Bleihüttenbetriebe. *By* DR. AUGUST HARPF. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv.*, *pages* 453-456 *and* 469-472.

The writer proposes to utilize tin-plate refuse in lead-works, instead of old iron. In the smelting-works at Pribram, in Bohemia, the raw ore is first roasted, then melted down into working-lead by the addition of suitable fluxes. Formerly, from 5 cwts. to 6 cwts. of metallic iron was used for nearly 10 tons of the ore, as a flux. In these mines, the ore is chiefly treated by roasting, and during the process the proportion of sulphur is reduced from 12 to 1·5 per cent., but cannot be wholly eliminated by this method. Therefore, the small residuum left in the roasted ore is soaked in the iron flux, to extract the lead. At Pribram, the lead thus obtained is first liquated, then freed from silver by the Pattinson-Rozan process, and the tin and antimony are separated by smelting in a refining-furnace with injections of air. The residuum of lead is very pure, and quite free from tin; the scum is collected, and melted down into an alloy. The Parkes process is also used in Bohemia, and sometimes no iron is added, but iron-bearing slag is taken from the roasted ore itself. Iron is also present as oxide in the roasted pyrites, and this is sometimes reduced and used as a flux.

Raw lead from the blast-furnace contains 0·5 per cent. of silver, 0·9 per cent. of copper, 0·2 per cent. of tin and sulphur respectively, and other metals. It is first purified by liquation and freed from copper, then refined, and the silver is separated by the Pattinson-Parkes method. The scum contains only 18 per cent. of tin, and is too poor for commercial purposes. It is therefore generally enriched by the Plattner process, namely, by heating it with 5 per cent. of coal in a refining-furnace, and subjecting the product to successive refinings. This does not seem, however, to be a wholly satisfactory method of treatment. At the Pribram works, the separation of the silver is said not to be complete, and the refined product still contains antimony. The process is also lengthy and costly, but as far as the writer is aware, it is the only one in use to extract the small quantity of tin in many lead-ores, and to make alloys poor in tin and therefore unsaleable into rich and marketable products.

To enrich these alloys with tin the author proposes to utilize tin-plate refuse as a flux. The project is not new. Various methods have been suggested, all based upon the separation of the tin from the iron, either by mechanical means, by liquation and the application of heat, or chemically, by dissolving in soda-lye or acids. Electrolysis has also been proposed, but although the price of tin is relatively high none of these systems seem to have found general acceptance, and

in many places tin-plate cuttings are still thrown away, which might, in his opinion, be usefully employed as a flux, instead of cast-iron, in lead-furnaces. Good tin-plate contains about 6 per cent. of tin, the rest being iron. As tin melts at 446° Fahr. (230° Cent.) it could soon be separated, and the iron would then act upon and decompose the galena. The tin would form a rich alloy with the lead which melts at 633° Fahr. (334° Cent.). The process is simple, and a valuable tin-alloy would be obtained, with no bye-products. The lead in the alloy would not cause any difficulty.

Against the process three objections may be raised :—

(1.) Whether the tin-plate refuse would be deposited and act in the same way as cast-iron refuse. This would certainly be the case. As soon as the temperature of the charge reached 446° Fahr. (230° Cent.) the tin would melt into drops and form an alloy with the lead already in the furnace. Liquid tin oxidizes easily when in contact with the air, and then readily forms a slag, if the tin has been extracted with acid slag and at high temperatures. Such oxidation of the metallic tin is not impossible, although it is generally assumed that, before this can take place, it is melted down with the lead and further oxidation is arrested. The proportion of tin in the ore is in any case not large, varying in the Pribram mines from 0·11 to 0·0? per cent. Before liquation was employed to reduce it the proportion was higher. We may further enquire whether the residuum of iron-plate left in the furnace after the tin had melted would scorify in the same way as cast-iron. Probably it would, because the iron does not melt by itself, but combines with other fluxes which melt more easily.

(2.) How will the tin act in the working-lead when liquated, treated by the Pattinson or Parkes method, or refined? According to experience it will during liquation remain in the lead, because of the low melting-point of the tin, its affinity with lead, and its readiness to combine with it to form alloys. The melting-point of pure tin is 446° Fahr. (230° Cent.), of pure lead 633° Fahr. (334° Cent.), and alloys of the two vary in their melting-point between these temperatures, according to the percentage of either metal. With the Pattinson method, large quantities of tin are injurious because they hinder the precipitation of the silver in the lead, but the small quantity found in liquated lead does not signify. Another point to be considered is the quantity of tin which would be found in the lead, if tin-plate refuse were used. The raw ore contains about 24 per cent. of lead. This is reduced in the furnace by the fluxes, and litharge or lead oxide is therefore added to bring up the proportion to about 19 per cent. Assuming that this percentage can be extracted if a flux of tin-plate refuse be used containing 6 per cent. of tin and 94 per cent. of iron, the tin will increase the lead by 0·32 per cent. If the impurities exceed 0·67 per cent., the ore should be either liquated or refined. Treated by the Parkes process, which is cheaper and now more generally used, the tin is said to have no injurious effect on the lead. Whichever method is employed, the writer urges that tin-plate refuse should be used as a flux in all mines in which the ore contains no silver.

(3.) Can a sufficient quantity of tin-plate refuse be procured to use in the way proposed? Certainly in large towns, though perhaps not in small ones. Birmingham alone produces nearly 20 tons per week, and Paris 54 tons per month. Such a utilization of refuse which is now often thrown away would be highly desirable. The tin in it could be turned to account in rich alloys, and the iron would replace the more valuable old-iron refuse now used in smelting-furnaces.

If when charging the furnace, it were found that a large quantity of the tin scorified and was lost, or that much refining was needed to get rid of the silver,

the writer suggests that part of the tin should previously be extracted by either the Edmunds or Patterson dry process, and only the residuum used for the alloy. Both processes are recommended. The Edmunds process yields pure tin or tinned lead; with the Patterson process, alloys poor in tin may be enriched, but by neither method can the tin be completely separated from the iron. If an alloy perfectly free from tin is desired, the two processes may be successively employed.

The whole question of substituting tin-plate refuse for iron as a flux turns upon the output from the smelting-works under consideration, and the difference in price between the two metals. The cost of smelting must also be taken into account. B. D.

IMPURITIES IN ALUMINIUM AND ITS ALLOYS.

Sur les Impuretés de l'Aluminium et de ses Alliages. By ED. DEFACQZ. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1897, *vol. cxxv.*, *pages* 1174-1177.

In attempting to ascertain the forms in which iron, copper and silicon occur in commercial aluminium, the author treated the metal with dilute hydrochloric acid, and then subjected to analysis both the solution and the insoluble brown residue. The products of the action of aqua regia and dilute hydrochloric acid on an alloy containing 100 parts of copper and 3 parts of aluminium were also examined. In the first two instances, the residue was found to possess the properties of impure silicon, whilst that from the action of dilute hydrochloric acid on the alloy yielded aluminium, iron, copper and silicon. Silica was detected in all the solutions, and was presumably formed by the decomposition of metallic silicides present. Owing to the circumstance that the impurities are distributed in both the soluble and insoluble portions of the substance, their separation by means of dilute acids is an impossible task. C. S.

ALLOYS OF GLUCINIUM.

Sur la Préparation des Alliages de Glucinium. By P. LEBEAU. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, 1897, *vol. cxxv.* *pages* 1172-1174.

Although the metal itself has not been prepared in a pure state, owing to the great heat necessary for the reduction of the oxide, conjoined with its volatility and tendency to form a carbide, successful attempts have been made to obtain it in the form of alloys. To this end, nitrate of copper and nitrate of glucinium are intimately mixed, reduced to the state of oxides by calcination, mixed with carbon and exposed in the electric furnace for 5 minutes. A rose-red coloured ingot is obtained, which, on fusing, yields a yellow alloy containing 5 to 10 per cent. of glucinium. With the lower limit of this metal, the alloy is malleable and can be filed or polished; it does not tarnish on exposure to air, but is discoloured by sulphuretted hydrogen. The alloys resulting from the fusion of the preceding one, with copper, are sonorous in a high degree. C. S.

TESTING OF SULPHUR.

Die Chemisch-technische Untersuchung der Schwefelblüten, beziehungsweise des Schwefelpulvers. By F. JANDA. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv. pages* 477-480.

Sublimated sulphur is obtained from refined sulphur, or in Italy direct from volcanoes. For ordinary purposes the cheaper sulphur, which is easily reduced to powder in grinding-mills, is preferred to the sublimated, and this flower of sulphur is chiefly used in chemistry. Powdered sulphur is a product of metallic sulphides and sulphates, and is obtained by the Chancel, Mond, Hoffmann and other processes. It resembles sublimated sulphur, but has not its beautiful yellow colour, and differs in being wholly soluble in bisulphide of carbon.

The quality of sulphur depends upon the geological stratum from which it is extracted, whether limestone, argillaceous marl or bituminous rock. The purest Sicilian sulphur is yellow, with whitish streaks. There are various kinds of sublimated sulphur, differing in price according to their appearance, colour and purity. Raw sulphur contains sometimes 20 per cent. of lime, magnesia, iron, clay, sand, bitumen and other impurities. If refined sulphur be heated in the open air it kindles at a temperature of 479° to 511° Fahr. and burns with a pale blue flame. It has a great affinity for oxygen, and volatilizes at ordinary temperatures. For this reason, sublimated sulphur is sometimes spread out near pans of water, as an antidote against mercury fumes. This property is due to the moisture in the sulphur combining with the oxygen in the water, but pure distilled water has no effect on it.

As sublimated sulphur is much used in medicine, its purity is an important point, and is tested in many ways. It is often determined by its colour, which should be a bright yellow; manufactured powdered sulphur is of a greyish hue, owing to the earthy particles in it. The moisture in pure sulphur is known by weighing it carefully, before and after drying—as a rule it contains very little. Its specific gravity varies from 1·98 to 2·10. The incombustible residuum which it contains is determined by burning a given quantity to ashes in a crucible, and weighing the result. Care must be taken not to heat the sulphur much beyond its ignition-point, otherwise it will escape as vapour. The mean residuum thus obtained is usually about 0·033 per cent., and this is further analysed for impurities. To test the solubility of pure sulphur in alkalis it is carefully heated with caustic soda, the mixture cleared and filtered, and the undissolved residuum dried and weighed. The fineness of powdered sulphur is sometimes determined in a Chancel sulfurimeter. A given quantity is shaken up with ether in a glass tube, and the height to which the layer of sulphur rises in the ether when allowed to settle shows its fineness. It is also sometimes tested mechanically by the touch, or rubbed through a very fine silken sieve, and all that does not pass the sieve is examined under a microscope. Its combustibility is determined by burning various samples carefully in a porcelain crucible, and comparing the time that each takes to burn.

Tests are also made to determine the chemical constituents of sublimated sulphur. The proportions of sulphuric and sulphurous acid which it contains are known by first boiling a given quantity in distilled water, to which a few drops of alcohol are added, then filtering the result, which, when thus treated, shows practically no trace of these acids. Arsenic is sometimes found in sulphur, especially if it be produced from Spanish pyrites, and reddish or dull yellow sulphur is always suspicious. To detect it, the sulphur is boiled with nitric acid, soaked in water, filtered, and carbonate of ammonium and a few drops of solution of nitrate of

silver are added. If the product shows a yellow deposit, arsenic is present. Another way is to treat it with sesquicarbonate of ammonia and hydrochloric acid ; or it may be tested with aqua regia, and the filtrate converted into a gas. The rare metal selenium is also occasionally found in volcanic sulphur. To test for it, the sublimated sulphur is boiled with concentrated potash lye. A dark red solution is obtained, and after long exposure to the air, or the addition of hydrosulphite of ammonia or of potash, the selenium is separated and forms a thin film on the surface. The same result may be obtained with a solution of cyanide of potassium diluted with hydrochloric acid. Another way is to treat with nitric acid, and evaporate the product with hydrochloric acid, when the selenium will be precipitated. This reagent has little effect unless heated. The presence of thallium is shown by the orange colour of the sulphur extracted from pyrites, and is detected by treating it with bisulphide of carbon, when nearly all the sulphur is separated. The residuum, when tested, is found to be chiefly thallium. Arsenic, selenium and thallium cannot be separated from the sulphur by rectification only. The presence of bituminous and organic substances is shown by treating the sulphur with sulphuric acid, and filtering the product through asbestos. B. D.

ANALYSIS OF BLACK TELLURIUM.

Ueber die chemische Zusammensetzung des Blättertellurs, Nagyágit. By DR. E. PŘIWOZNIK. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1897, *vol. xlv., pages* 265-267.

Black tellurium or tellurium-ore has often been submitted to quantitative chemical analysis, but the results have varied so widely that it has not hitherto been possible to define its chemical composition. The formulæ given by Dr. Rammelsberg are based upon electro-chemistry, and show only the proportions by weight of the positive components, gold and lead, to the negative components, sulphur, tellurium and antimony. The formula of Prof. Gmelin-Kraut is equally inapplicable for black tellurium because, as the writer proceeds to show, the proportion of white antimony in the ore, on which the formula is based, is probably mixed with grey antimony. In analyses made by different chemists, the proportion of tellurium varies from 13 to 32 per cent., and of sulphur from 3 to 11·7 per cent. Some give silver, some antimony, as present, and the quantity of gold also increases from 6 to 12 per cent. These differences might almost lead to the conclusion that black tellurium varies in its composition, and is formed of a mixture of compounds which fluctuate in their relative amounts.

Probably, however, these discrepancies are produced, partly by impurities in the samples, partly by the difficulty of analyzing them. Even with the utmost care, the results obtained are often contradictory. The writer, therefore, undertook a series of trials with samples as pure as possible, to check analyses made at the Göttingen chemical laboratory. The results agreed fairly well, the chief difference being that the Göttingen trials gave 1·13 per cent. more gold. The quantities used were 1·1038 grammes of finely powdered mineral, yielding 0·0172 gramme of quartz, 0·0881 gramme of gold, 0·8138 gramme of sulphate of lead, and 0·4902 gramme of telluride of sulphur. These tests having shown that black tellurium is a chemical compound of well-defined composition, the formula hitherto used was revised, and a fresh one substituted for it, namely $Te_{12}Pb_{12}AuS_{16}$, founded on analyses which gave about 30¾ per cent. of tellurium, 10 per cent. of sulphur, 8 to 8¾ per cent. of gold, and 50 per cent. of lead.

According to Dr. Wöhler, black tellurium is a mineral composed of telluride of sulphur, galena, telluride of lead and telluric gold. Taking these as a basis, its composition may be expressed as follows:—4 PbS, 2 PbTe, $AuTe_2$ + 2 TeS_2. The three latter compounds may be present in varying quantities, combined with small amounts of telluric silver and copper. The writer, however, is of opinion that the composition of black tellurium cannot be represented graphically. The actual chemical structure of a body, that is the arrangement of the atoms in the molecules, cannot be given by a formula, because the latter takes no count of their division in space. Here a combination of no less than 21 atoms of 4 different kinds takes place, and it may safely be asserted that the so-called structural formulæ are not so desirable in mineralogy as in organic chemistry. B. D.

REFINING OF TELLURIUM.

Ueber die Reinigung des Rohtellurs. By DR. E. PŘIWOZNIK. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv.*, *pages* 219-222.

Tellurium, as prepared in different ways from the tellurium-ore found at Nagyag in Hungary, is not sufficiently pure for scientific purposes. It is still in a raw state, and contains lead, copper, antimony, arsenic, bismuth, iron, manganese, sulphur, and even limestone and magnesia. Precipitated tellurium has also tellurous acid mixed with it. In a sample of light-grey pulverized tellurium tested by the writer, 40 per cent. of tellurous acid was found, and in another, said to be pure, 6 per cent. of gold. The presence of the rare metal, thallium, combined with tellurium, has also been verified by different chemists. Several quantitative analyses of raw tellurium have been published, and these show that sulphur, selenium, arsenic, antimony and bismuth are the impurities most frequently met with, because the tellurium cannot be freed from them by smelting, but their proportions vary greatly. When zinc was used to precipitate solutions of tellurium, they were found, after treatment, to contain from 60 to 80 per cent. of impurities, namely, 13 per cent. of lead, 14 per cent. of copper, 11 per cent. of antimony, 1 per cent. of zinc, about 5 per cent. of iron, 2 per cent. of sulphur, 1½ per cent. of water, etc.

Without a chemical analysis, the purity of precipitated tellurium cannot be known, but, if smelted, defects in its composition may be detected at a glance. If impure, it is earthy looking and dark, while pure tellurium is steel-grey, has a metallic appearance, and the surface, as it cools, is beautifully marked. In colour it is not "silvery-white" as often described. Pure liquid tellurium, and tellurium sublimed in hydrogen gas, is steel-grey, with a metallic glitter. An expert will never mistake it for any other mineral, although in colour and brittleness it is like antimony.

Since this remarkable chemical element, which resembles a metal in its physical, and sulphur in its chemical properties, is only used for scientific purposes, it is very important to have it pure. Sixty-grade powdered tellurium is sold in Austria at about 28s. per pound, while liquid tellurium costs 64s. per pound. Small bars of sublimated tellurium are actually worth more than the same weight of gold, being sold at 8s. per gramme, or nearly £182 per pound.

The methods hitherto used to purify raw tellurium are to dissolve it and then separate the tellurium from the clear solution by precipitation. The foreign substances remain in the solution, and are withdrawn by filtration or by pouring them off. There are four ways of thus treating tellurium, according to the re-

agent employed; to each of them a special chemical formula belongs and each has been tried by different eminent chemists. At the Hungarian Government refining-works at Schemnitz compressed fluid sulphur dioxide is used, contained in cast-iron cylinders, and it is also sometimes applied in a gaseous state. If this method be followed, the raw tellurium is first dissolved in hydrochloric acid, to which nitric acid diluted with an equal quantity of water is added. The solution is greatly diluted, and a little tartaric acid is sometimes mixed with it, to prevent separation of the white antimony and telluric acids. If sulphurous acid be used in a gaseous form to precipitate the solution of tellurium, a curious phenomenon takes place. If the solution contains much hydrochloric gas, only a small part of the tellurium will be precipitated, and no further separation takes place, even if the solution be reheated and boiled. But if water be added, separation immediately begins afresh, and all the tellurium will be precipitated if sufficient sulphurous acid has been absorbed. This interesting fact is important, because if precipitation be incomplete much of the tellurium may be lost.

In view of the effect produced by the hydrochloric gas, Dr. Brauner recommends, when treating solutions of tellurium in hydrochloric acid, to dilute first with water and afterwards with gaseous sulphurous acid. By these means, he succeeded in precipitating 53 per cent. of the original raw tellurium. Many chemists doubt whether tellurium can be purified by precipitation with sulphurous acid. Prof. Berzelius says that it may be thus reduced. but not purified, because selenium, gold, copper, bismuth and iron may be found in it after precipitation. This case, however, need not be considered here, because in commercial tellurium there is no gold. If the solution of tellurium contains selenium it can be completely freed from it by exposing it in a molten state for a long time in hydrogen gas, when the selenium will be evaporated. If the tellurium-solution be not diluted till it has absorbed an excess of sulphur dioxide, the precipitated powder will be purer than if this precaution be not observed, otherwise telluric acid, copper, lead, etc., will be found in it, and will render it much more difficult to smelt.

Alkaline sulphates may also be used cold to precipitate tellurium. The liquid is left to stand from 12 to 24 hours, filtered, and the precipitate washed with diluted sulphurous acid and water. The solution should always be strongly acid. The filtered liquid is then well boiled, and again similarly treated, when a little more tellurium is extracted. Another method to purify tellurium is first to obtain tellurous acid (or dioxide of tellurium) from the raw mineral, and by oxidation with chromic acid to transform this into telluric acid, which is then reduced.

It is evident that if all these processes of repeatedly dissolving and precipitating tellurium be employed, a purer product will be obtained than by a single precipitation. The last particles of foreign substance may be eliminated by electrolysis, by distilling the tellurium in hydrogen gas, by bringing it to a red heat in an ordinary blast-furnace, and distilling it over in a small porcelain retort, or by fractional distillation. At Schemnitz, it is melted down in clay crucibles in the muffle of an assaying-furnace, and various fluxes are added to it. If hydrogen gas be used, however, the sulphur and selenium escape, the tellurium acids and their compounds are completely reduced, and pure tellurium is the result.

Liquation, or fusing the mineral in hydrogen gas, cannot be applied to raw tellurium which contains 40 per cent. of impurities. If thus treated, it forms separate drops, but they will not fuse, because of the unmelted tellurides. The writer has liquated tellurium in small quantities in glass and porcelain tubes. As soon as the tellurium began to melt, the tube was so manipulated as to separate

the melted tellurium from the unmelted powder. If a little borax, which melts at 1042° Fahr. (561° Cent.) be added, it absorbs the foreign elements, and adheres with these to the glass. From 1 pound of raw Hungarian 60 grade tellurium, the writer obtained, by liquation, pure tellurium, which was then remelted in glass tubes in hydrogen. Upon cooling, it yielded smooth hemispherical buttons, the surfaces of which were covered with beautiful markings. The congealed tellurium in the globular part of the tube separated naturally from the glass by shrinkage, with a slight noise as if the glass had been struck. The buttons weighed from 24 to 37 grammes each. The delicacy of their tracings and their metallic glitter made them excellent samples for chemical collections, while the little cracks in them showed the crystalline structure of the metal. B. D.

SALT-PRODUCTION OF SIBERIA.

Die Salzgewinnung in Sibirien. By F. THIESS. *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate*, 1898, *vol.* *xlvi.*, *pages* 249-251.

The production of salt in Siberia is very far from adequate to the demand, and it is found necessary to import considerable quantities of the commodity from European Russia (*via* Odessa and Vladivostok), from Mongolia, and other countries. In the ports on the Pacific seaboard, foreign salt is imported free of duty.

In such districts of Siberia as possess workable salt-deposits, the placing of the salt on the market is often greatly hindered by the vile state of the roads, when there are any, and, as a consequence prices rule high. It is true that the State has established in various localities salt-storehouses, whence the inhabitants may supply their needs at a comparatively moderate cost. Even so, however, prices vary greatly from place to place.

In Western Siberia, the only local sources of salt are the innumerable salt-lakes scattered over the Government of Tobolsk, in the south-west of the Government of Tomsk, and in the provinces of Akmolinsk and Semipalatinsk. In very hot summers, salt deposits on the lake-shores to a thickness of 4 inches. The entire surface of the country between 47° and 55° latitude north and 63° and 73° longitude east of Paris forms a vast basin which at one time was covered by the sea.

As to the northern portion of this basin, in the Barabinsk and Kulundinsk steppes, no one lake yields common salt free from the admixture of other compounds, such as sodium sulphate. In the southern portion of the basin, on the other hand, in the waterless steppes of Akmolinsk and Semipalatinsk, the lakes yield a very pure salt, immediately available for edible purposes. Among the most notable of these lakes is that of Karyakovsk, which extends over an area of 9 square miles: the portion covered by salt-deposits measures about 4 square miles, and, in the middle of the lake, the thickness of the salt-layers exceeds 40 inches. In 1896, 11,834 tons of salt were got from this lake, but this is by no means the greatest amount produced in one year. Moreover, the official statistics represent only about a quarter of the actual output, as the Imperial authorities allow the Kirghiz nomads who range these southern steppes to take from the lakes without check or hindrance as much salt as they choose.

Mention must also be made of the Borovié and Burlinsk lakes in the south-west of the Government of Tomsk, in the so-called "salt steppe." The total

length of the shores of Lake Burlinsk exceeds 19 miles: the inhabitants of the neighbouring country, after selling their grain at Pavlodar, usually take salt as a return freight, and the commodity finds its way thence far into Eastern Siberia.

Glauber's salts are got from the Great and Little Marmishansk lakes in the same Government (Tomsk), 125 miles south-west of Barnául. The total area of these two lakes is about 2¼ square miles, and the layers of sulphate attain a thickness of 2 feet even at a couple of hundred feet from the shore. The annual production averages 1,610 tons, part of which goes to the soda-works at Barnául, part is used for smelting ores in the Altái, and the remainder in glass-manufacture.

Eastern Siberia is rich in common salt, which is mainly got from rock-salt deposits. These occur, however, in sparsely-populated districts, and are at present worked only on a small scale. In the Governments of Yenisseisk and Irkutsk, brine-springs were tapped at Tumanshetsk (20 feet deep), Tróitsk, Ust, Kut, etc. Numerous bitter-salt lakes occur in the first-named Government; while in Yakutsk, in the Vilyuisk district, are three rock-salt deposits.

The author tabulates the annual statistics of salt-production in Siberia from 1887 to 1896 (both years inclusive) From these it is seen that the Siberian output, averaging 35,000 tons, is hardly more than one-fortieth of the total salt-production of the Russian Empire. The labour statistics show that in 1894, in the salt-works of the whole of Siberia, 1,581 workpeople were employed, most of whom were convicts whose good conduct had secured them a mitigated form of penal servitude.

L. L. B.

MANUFACTURE OF SALT-BLOCKS.

Ueber die F. J. Müller 'sche Salzbriquettes-Presse in Ebensee. By Prof. HEINRICH GOLLNER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1897, *vol. xlv., pages* 139-144 *and* 156-159, *and* 1 *plate.*

Block-salt has hitherto been used in Austria as an article of food, but as a marketable commodity it is not satisfactory. It is coarse, irregular in shape, difficult to transport, absorbs much water, and there is great waste in cutting it. It cannot be closely packed for sending to a distance, nor can the weight of each piece be accurately known, when judged only by the eye or touch. These disadvantages disappear if it is prepared for use by mechanical means. The Austrian Government therefore determined to introduce a better system of supplying salt for domestic purposes. Instead of bringing it into the market in the rough state, they resolved to have it manufactured into blocks of a given weight and shape. This was not a new process. The history of block-salt manufacture dates back in Austria to 1858, in which year its production by mechanical means was first advocated. Practical experiments were made in 1873, and various systems of hand-presses introduced at Ebensee. From that date their manufacture steadily improved: the first machine-press was made in 1891.

Two standard shapes were selected by the Austrian authorities. The first, in use at the Ischl salt-works, was a prism measuring 2·9 inches by 3 inches by 5·8 inches, and weighing 2·2 pounds. The second, employed at the Ebensee salt-works, was a cube measuring 3·7 inches each way, and made in two sizes, weighing respectively 2·2 and 11 pounds. At the Ischl works, the Meyer machine, introduced in 1896, is used, and the Müller, brought out in 1895, at Ebensee.

It was impossible to sell such small blocks of equal weight at a profit, unle produced by machinery and in large quantities. To turn out blocks of refined sa

of a certain quality and without a flaw suitable machinery was required, and these conditions were provided by the hydraulic salt-press made by Messrs. Muller & Cie., of Prague The machine consists of a cylindrical hydraulic block-press. two hydraulic delivery-presses, an accumulator, and a high-pressure pump. The main hydraulic and two delivery-presses are all placed on the same baseplate, the hydraulic press being in the centre, and the delivery-presses, which it serves alternately, on either side of it. The piston of the hydraulic press is 14 inches in diameter and 4·3 inches stroke, and each up (motor) stroke compresses 12 blocks. Above the piston is an iron plate connected by two vertical columns to a weight at the top of the engine, which is so adjusted that the downstroke of the piston takes a shorter time than the upstroke. Four strong columns support the fixed cover of the mould, the lower surface of which forms a 12 celled bed-die of phosphor-bronze. The cast-iron mould resting on the hydraulic piston is square, and contains 12 four-sided divisions or cells of the same metal. The bottom of each cell is closed by a piston 3½ inches in diameter, which forms a kind of die or stamp-cutter, worked upwards from below, and all these pistons rest on one plate. As the lower part of the mould filled with salt is brought beneath the upper part, or stationary cover, it is gripped by a 4 armed lever, the hydraulic piston rises, the upper weight descends, the two halves, upper and lower, of the mould are brought together, and the salt is cut out into cubes, and greatly compressed by the continued upward movement of the main and the stamping pistons. The cylindrical press is provided with valve-gearing, and when the process of compression begins, the valve sends the water into the piston from the accumulator, whence it is returned to the high-pressure pump. The mould can be easily withdrawn from the machine if required, or the number of cells in it can be varied.

The cylindrical press is connected to the delivery-presses on either side by slides, along which the mould is run easily and quickly from one to the other, and back again. In these presses, the cubes are turned out of the mould, and each seized separately by small aluminium pincers, and placed in sets of three upon an iron plate, to be conveyed to the drying-oven. The operation takes only 2 seconds. The pistons of these presses work upwards, and have a stroke of 7·3 inches. The upstroke discharges the blocks, the downstroke corresponds with the downstroke of the main piston, carrying the empty mould, which is then filled afresh with salt. Each delivery-press is worked by valve-gear, similar to that of the main press.

The working of the salt-press is as follows:—The purified salt is first weighed by two workmen in two small gauged trucks, which, when full, contain the right weight. The salt falls into a leaden box with 12 partitions closed below with a slide-valve. This box is made in two halves, corresponding to the two sides of the hydraulic main press. When filled with salt, it is placed above the emptied mould, at the top of one of the delivery-presses, the slide-valve is withdrawn, the mould filled automatically, and pushed along the little rail to the main press, where the process of compressing and delivering another set of blocks has just been completed. The piston of the latter is now in its lowest position. The mould is run on to it, the valve-gear connected to the water in the accumulator, and the piston begins to rise. Four hooks at the corners of the mould are caught by tappets on the 4 armed lever, the mould is raised to the bed-plate, and the two lock together. As the piston continues to rise, the 12 stamping-dies or cutters are driven up, and the salt in each cell is forced up into the bed-plate, where the actual process of compression takes place. This completed, the valve opens to

discharge the water, and the piston falls. The mould is drawn down by the hooks till it reaches the rails, along which it is pushed by hand on small wheels. As soon as it reaches the delivery-press, the water is again turned on, the delivery-piston rises, and the blocks are discharged from the machine. As the latter is in duplicate, the mould is emptied and refilled on one side of the hydraulic press, while, on the other, the blocks are stamped and compressed.

The efficiency of the machine depends on the play of the mechanism, and the number of cells in use. The time occupied in the different processes is as follows:—Weighing and filling the box 8 seconds, filling and cleaning the mould 10½ seconds, upstroke of the pressure-piston 6·3 seconds, downstroke of the pressure-piston 8·2 seconds, discharge of the 12 blocks 2 seconds, and complete compression-stroke, and interval till beginning of next stroke 1 minute. The total output during a 10 hours day with a 12 celled mould in duplicate is 14,515, or say 15,000 blocks. Five men are required for the work, 2 to weigh the salt and fill the box, 2 men, one on either side of the machine, for pressing and discharging the blocks, the fifth helps the last two, alternately. Each truckload of blocks for drying contains 500. The blocks weigh 2·2 and 11 pounds, respectively; the edges are slightly rounded, and the surfaces scored at proper intervals, in order that the blocks may be easily divided into pieces of one-half and one-quarter of the original weight.

The efficiency was submitted to careful tests by the writer. The machine was experimented on with moulds containing 12, 9 and 6 divisions, and the results plotted on a curve in the original paper. The number of divisions formed the abscissæ, the efficiency the ordinates during a 10 hours working day. With a mould with 6 cells 10,000, with 9 cells 12,800, and with 12 cells 15,000 blocks of 2·2 pounds weight were turned out per day. The quantity of water required per block to work the compressing and the delivery-presses was 61 cubic inches (1 litre). As, however, the water is used in a continuous cycle in the high-pressure pump, it is only necessary to calculate one filling of the accumulator, and the supply to replace loss by waste.

The mechanical work required for the different operations was determined in each successive phase of work from the total time occupied, the dimensions of the machine, load and total quantity of water per cycle. To obtain a pressure of 54 atmospheres the load on the main piston, deducting friction, was 20,275 pounds, and total horsepower per stroke 12·3. Of this, 0·3 horsepower was expended at the beginning of the stroke, while the piston did no external work, 10·3 horsepower during the period of compression, which occupied 5·8 seconds, with a mean effective pressure of 44 atmospheres, while 0·59 horsepower must be assigned to the delivery-pistons. The balance, namely, 1·1 horsepower, was expended in overcoming the frictional resistance of the moving parts, making a total of 12·3 horsepower, or in round numbers 1 horsepower per block produced. The static pressure of 54 atmospheres sank to 44 atmospheres at the end of the stroke, a fall due principally to friction. The various data thus collected are plotted on curves in the original paper. The efficiency of the hydraulic press varied from 93 to 96 per cent., and the coefficient of friction from 12 to 19 per cent.

The writer tested the blocks in a technical mechanical laboratory, in various ways, for uniformity of composition and resistance to pressure. The results showed that their elasticity of compression increased from the top of the cube, where the pressure was greatest, downwards. The prism-shaped Ischl blocks were also tested, of course with greatly differing results owing to their different shape. The line of least compressive strength was, however, in both kinds found to be

next the lower surface. To determine the resistance of the blocks to a sudden strong pressure, upon which the efficiency of the machine depended, and therefore the output from it, the time required for the piston of the machine to reach the end of its stroke, that is, the actual duration of pressure was noted. It was found that a period of 6·3 seconds was needed to produce 12 blocks, this being the maximum number which could be satisfactorily manufactured at one time. The pressures used in the laboratory were from 10 to 175 atmospheres, and they were applied from 15 to 75 minutes. Irregularities in the speed of the pressure-piston were also tested, and, with the output of the machine and other data, were plotted on curves. B. D.

HASSELMANN METHOD FOR PRESERVING TIMBER.

Uber das Hasselmannsche Imprägnierungs-Verfahren, speziell in seiner Bedeutung für das Grubenholz. By DR. MAX KRAUSE. *Glückauf*, 1898, *vol. xxxiv.*, *pages* 760-764.

Inasmuch as unimpregnated timber is not suitable for use in mines on account of the special conditions of temperature that prevail underground, and its tendency to rapid decay from damp, some preservative process becomes necessary; but the three methods of timber-preservation most employed have given but little satisfactory result. Whereas efforts have hitherto been made to fill the wood cavities with a more or less antiseptic substance, in the Hasselmann method not only are the cell-walls and the wood-fibre penetrated, but even a chemical combination is directly set up between them and the dissolved chemical constituents of the impregnating substance. This is effected by two boilings, each of which lasts from 3 to 4 hours, during which solutions—in the first case of cuprous sulphate of iron and subsulphate of alumina, and in the other of calcium chloride and corrosive sublimate—are injected into the wood so as to chemically combine with it, in a close chamber at a temperature of 275° to 284° Fahr. (135° to 140° Cent.), corresponding with a pressure of about 41 pounds per square inch (2½ to 3 atmospheres) above atmospheric pressure, the effect being very remarkable. The resin in the wood is dissolved and decomposed; the fibre spores are completely destroyed; and all the cells, even the innermost in the false heart of beech, are penetrated, and enter into indissoluble chemical composition with the impregnating substances.

Not only all species of timber – mine-timbers and railway-sleepers, for instance – but also vegetable and textile substances generally, may be treated by this process with the most manifold advantages; and that timber so impregnated really does resist decay in a remarkable degree is conclusively proved by the trials conducted by Prof. Rösler, Director of the Austrian State Testing-station, Klosterneuburg, the conditions having been rendered as severe and unfavourable as possible for a short period, in order to compensate amply for the usual influence of long duration. In a water-course, dry in summer and generally frozen in winter, piles impregnated according to this method were driven alternately with others not impregnated; and about a year afterwards it was found that the treated piles of all the woods chosen were perfectly sound, the portions that were in the ground having even become harder, while fir, beech and oak piles not treated showed various stages of decay.

The author endorses the assertion made by Prof. Heinrich Mayer, that Hasselmannized timber retains all the properties which are so important for application in the arts, especially elasticity, that it attains a degree of hardness apparently impossible without great increase of weight, and that its combustibility is considerably reduced. J. W. P.

PROTECTION OF STEAM-HEATED SURFACES.

By Charles L. Norton. *Technology Quarterly and Proceedings of the Society of Arts, Massachusetts Institute of Technology,* 1898, *vol. xi., pages* 196-210, *and* 2 *figures in the text.*

The method adopted, which the writer believes is original, in making the experiments, was as follows:—A length of steam-pipe was heated by electricity from the inside, the amount of electrical energy was measured, and consequently the amount of heat furnished was known. If the steam pipe be kept at a constant temperature by a given amount of heat, it is because that amount is just equal to the heat that it is losing; for if the supply were not equal to the loss, the temperature would fall. In other words, the heat put into the pipe is equal to the loss by radiation, convection and conduction. By measuring the electric energy supplied one can determine the heat used and consequently the heat given out or lost.

The apparatus used in making the tests by this method comprized several lengths of steam-pipe of different diameters and lengths, heated electrically from within by means of coils of wire immersed in oil. The oil was stirred vigorously, and served as a carrier of heat from the wire to the pipe. Table I. shows the results of the first series of experiments.

TABLE I.

Specimen.	Name.	Loss per Square Foot of Pipe-surface per Minute.	Ratio of Loss to Loss from Bare Pipe.	Thickness.	Weight per Foot of Length, 4 Inches in Diameter.
		British Thermal Units.	Per Cent.	Inches.	Ounces.
A	Nonpareil cork standard	2·20	15·9	1·00	27
B	Nonpareil cork octagonal	2·38	17·2	0·80	16
C	Manville high-pressure	2·38	17 2	1·25	54
D	Magnesia	2·45	17·7	1·12	35
E	Imperial asbestos	2·49	18·0	1·12	45
F	Felt, with lining of asbestos paper	2·62	18·9	1·12	59
G	Asbestos air-cell	2·77	20·0	1·12	35
H	Manville infusorial-earth	2·80	20·2	1·50	—
I	Manville low-pressure	2·87	20·7	1·25	--
J	Manville magnesia-asbestos	2·88	20·8	1·50	65
K	Magnabestos	2·91	21·0	1·12	48
L	Moulded sectional	3·00	21·7	1·12	41
O	Asbestos fire-board	3·33	24·1	1·12	35
P	Calcite	3·61	26·1	1·12	66
—	Bare pipe	13·84	100·0	—	—

Table II. shows the varying loss from bare pipes when their surfaces were in varying conditions as regards rust, dirt, paint, etc.

TABLE II.—LOSS OF HEAT, 200 POUNDS PER SQUARE INCH, FROM BARE PIPE.

Condition of Specimen.	Loss per Square Foot per Minute. British Thermal Units.
New pipe	11·96
Fair condition...	13·84
Rusty and black	14·20
Cleaned with caustic potash inside and out ...	13·85
Painted dull white	14·30
Painted glossy white...	12·02
Cleaned with potash again	13·84
Coated with cylinder oil	13·90
Painted dull black	14·40
Painted glossy black...	12·10

Table III shows the varying loss from a bare pipe with the change in pressure.

TABLE III.—VARIATION OF HEAT-LOSS WITH PRESSURE.

Pressure. Pounds per Square Inch.	Bare Pipe Loss per Square Foot per Minute. British Thermal Units.
340	15·97
200	13·84
100	8·92
80	8·04
60	7·00
40	5·74

M. W. B.

ELECTRIC PLANT AT THE BLANZY COLLIERY.

Installation électrique des Mines de Blanzy. By L. GOICHOT. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1898, *pages* 202-204.

This important power and lighting-plant comprizes four lines, two of which were brought into operation last year. At the central station, steam is raised in six MacNicoll boilers, with forced draught, and fired for the most part with refuse from the washing-floors. The 300 horsepower Willans and Robinson steam-engine, making 350 revolutions per minute, is coupled directly with the generating dynamos by Raffard clutches, the yield in 5,000 volts current being 92 per cent. with full load. This high-tension current, led by overhead wires, uninsulated except when crossing public roads, is transformed, at each secondary centre of distribution, into one of 125 volts for driving small motors and lighting, and to 700 volts for driving the underground electromotors; the iron boxes of the transformers being connected with earth for preventing accident. The triphase electromotors are provided with rings and brushes, which permit of resistance-coils being switched into their circuit, either on starting or when it may be desired to reduce the speed of a running motor.

The principal electromotors already erected are one of 65 horsepower, making 580 revolutions per minute, for driving the chain-haulage of the Saint-François pit; another of the same power for driving an underground pump at the level of 843 feet (257 metres) in the Magny pit; a 40 horsepower and a 30 horsepower for driving a haulage-plant in the same pit; a 15 horsepower driving an underground

Mortier fan of 3¼ feet (1 metre) diameter, which delivers 212 cubic feet (6 cubic metres) of air per second, at a water-gauge of 1·2 inches (30 millimetres), and several small motors, including one at the Sonde gobbin-quarry, serving an incline and utilizing the high-tension current.

The transforming-stations also maintain, both underground and on the surface, a great many arc and incandescent lamps. The high-tension current adopted is justified by the length of the lines, one of which measures 5 miles (8 kilometres). The net useful effect obtained from the large continuously-running motors, like the pump, is 44·4 per cent. in water raised, and 70·8 per cent. of the actual transmission of energy between the engine-shaft and that of the electromotor, while it may be considered that the whole plant collectively, including the small as well as the large electromotors, affords a yield of 60 per cent. J. W. P.

ELECTRIC DRIVING AT THE GLÜCKAUF SALT-MINE, SONDERHAUSEN.

Der Elektrische Centralbetrieb der Gewerkschaft "Glückauf" zu Sondershausen. By BERGRAT GRÖBLER. *Glückauf*, 1898, *vol. xxxiv., pages* 953-967, *with plans, sections, and photographic views in text, and* 5 *plates.*

Where electricity can be employed it has entirely superseded compressed air, owing to its easier application and the high useful effect of the electromotors, but chiefly on account of the greater economy of electricity for intermittent working, such as that of rock-drills and mine engines. In the intervals between working, during which an electromotor does not require to exert any power, it receives no current from the conductors or generating-station, so that there is no loss; but on the other hand, with compressed air, even while the motor is standing, the loss caused by leakage still continues—a matter of no slight importance when the pipes are long and have several branches.

The central station, the mine-fan, the rock-salt mill, chlorate-of-potash works, coal-supply, waterworks, 20 cwts. lift at pit-bank, workshops, electric-lighting and underground working of the Glückauf mine are described. The 500 volts current is led down the shaft to the landing by a steel-armoured cable 2·40 inches (61 millimetres) in diameter with three copper wires each of 0·108 square inch (70 square millimetres) cross-section. Current of the original tension is supplied to the electromotors for driving winches and small auxiliary fans, but reduced by transformers to that of 220 volts for rock-drills and electric lighting.

Altogether there are 24 electromotors in the Glückauf mine—16 on the surface and 8 underground—varying from 1¼ to 105 horsepower; and it is only the large types—those of 105 horsepower for the mills—that require constant attention, the others being looked after by men while going their rounds, which is quite sufficient, because all the motors are provided with ring lubrication.

Every month, all the electromotors are thoroughly inspected, under the supervision of the engineer, while the resistance in the conductors is measured, so that any defect may be at once remedied.

The electric plant, which was started on June 1st, 1897, has left nothing to be desired; and the dependence that can be placed upon it is as complete as it is possible to attain, while a maximum of safety is secured. Touching a conductor

of 500 volts current is not fatal under ordinary circumstances; but nevertheless all the leads in buildings and places where the workmen pass are insulated, while danger of fire through short-circuiting is practically avoided.

In comparing the first cost of mining plant with and without driving from an electric central station at first sight the outlay in the former case, with its carefully constructed engines and dynamos, would appear to involve greater expense, while the electromotors underground are not much cheaper than steam-engines; but at the same time the fact must not be lost sight of that the electromotor only requires a slight proportion of the space necessary for a steam-engine of equal power, and consequently only smaller and simpler (if any) foundations and special engine-rooms. At the Glückauf mine, there are electromotors which, if not simply laid down in the workings, are only separated therefrom by brattice. With electric driving, whether direct or in groups, there is no heavy gear for transmitting power, so that there is less brickwork; and the buildings may be of lighter construction. J. W. P.

STAVE-PIPES: THEIR ECONOMICAL DESIGN AND THE ECONOMY OF THEIR USE.

Proceedings of the American Society of Civil Engineers, 1898, *vol. xxiv., pages* 676-708.

At first, stave-pipes were principally used for penstocks in the development of water-power, and were built in tapered sections, which were put together after the manner of stove-pipes. The first instance of their use as a continuous tube was the 6 feet penstock constructed at Manchester, New Hampshire, in 1874, and which is still doing service.

The particular type referred to in this paper is that of a pipe which is built, continuously in the trench, of staves of variable length, having radial edges and concentric faces, and held together by metal bands, usually circular in section, and spaced in accordance with the strain imposed.

In the construction of a wooden pipe, the staves must be thin enough to secure complete saturation and to deflect readily to the degree of curvature employed, and they must be thick enough to prevent undesirable percolation through them. The bands must be of such a size that when spaced to secure the desired factor of safety against rupture, there will be at the same time no sensible flexure in the staves and no destructive crushing of the fibre beneath the band. While fulfilling these conditions, the proportion between the thickness of the staves and strength and spacing of the bands must be such that the swelling of the wood will not produce injurious strains upon what might otherwise be a properly proportioned band.

Table I. contains details respecting the construction of 12 existing sections of stave-pipes, and is self-explanatory.

In addition to the discharging capacities of stave-pipes being superior to those made of cast-iron or riveted-steel pipes, the economy of their use is shown by Tables II. and III.

It would appear therefore that stave-pipes stand unquestionably first in point of first cost and carrying capacity when contrasted with the two other classes of pipes which are employed, and second only to cast-iron in length of life.

TABLE I.—STRAINS IN SOME EXISTING PIPE-LINES.

Number.	Location of Pipe.	Date of Construction.	Nominal Diameters.	Length.	Thickness of Staves.	Kind of Wood.	Character of Round Bands.	Ultimate Strength of Bands.	Maximum Band Spacing.	Pressure for Maximum Spacing.	Minimum Band Spacing.	Pressure for Minimum Spacing.	Band Strain from Water-Pressure.	Band Strain from Least Practicable Cinching.	Resulting Band Factor, neglecting Strain from Swelling Staves.	Band Strain from Swelling Staves.	Resulting Factor in Band, including all Strains.	Least Band Pressure on Staves per Linear Inch to maintain Tight Pipe.	Least Band Pressure on Staves per Square Inch to maintain Tight Pipe.	Total probable Band Pressure on Staves per Linear Inch of Band.	Total probable Band Pressure on Staves per Square Inch of Band Contact.
			Ins.	Miles	Ins.			Lbs.	Ins.	Feet.	Ins.	Feet.	Lbs.	Lbs.		Lbs.		Lbs.	Lbs.	Lbs.	Lbs.
1	Denver, Colorado ..	1889	30	18·00	1⅜	—	1¼ inches upset .	11,800	12	32	—	—	2,600	538	3·90	2,010	2·34	182	729	303	1,212
	" "	—	—	—	—	—	—	—	—	—	2·23	172	2,500	538	3·90	373	3·46	182	729	205	820
2	Provo, Utah .. .	1891	14	3·70	1⅜	Redwood	⅝ inch plain ..	5,300	18	25	—	—	1,367	402	3·00	—	—	211	1,126	—	—
	" " ..	—	—	—	—	—	—	—	—	—	2·75	165	1,344	396	3·00	378	2·50	208	1,108	253	1,349
3	Caldwell, Idaho	1890	54	0·13	1½	Pine .	½ inch plain ..	6,300	—	—	6·00	60	3,515	327	1·64	1,005	1·30	134	536	169	676
4	Butte, Montana . .	1892	24	9·00	$1\frac{1}{16}$	Redwood	½ inch upset ..	—	6	82	—	—	2,562	461	3·9	864	3·04	225	900	289	1,156
	" "	—	—	—	—	—	—	—	—	—	2·44	202	2,562	461	3·9	351	3·60	225	900	251	1,004
5	Bear Valley, California	1893	52	0·41	2·00	Redwood	⅝ inch upset —	17,200	12	28	—	—	3,791	437	4·06	2,400	2·60	151	483	236	757
	" "	—	—	—	2·60	—	—	—	—	—	2·00	165	3,724	558	4·00	520	3·58	150	479	168	537
6	Logan, Utah	1893	18	1·60	$1\frac{1}{16}$	Redwood	⅝ inch plain ..	5,300	12	18	—	—	844	202	5·08	1,728	1·91	100	533	268	1,417
	" "	—	—	—	—	—	—	—	—	—	4·00	53	828	200	5·08	576	3·30	99	525	154	826
7	Los Angeles, California	1895	24	1·00	1⅜	Redwood	—	9,000	12	23	—	—	1,562	269	4·92	1,650	2·58	137	414	260	785
	" "	—	—	—	—	—	—	—	—	—	4·00	83	1,833	315	4·20	550	3·34	161	486	202	610
8	Astoria, Oregon	1895	18	7·50	1⅜	Fir ..	$\frac{9}{16}$ inch upset	9,000	12	25	—	—	1,166	269	5·56	1,650	2·75	138	631	297	1,338
	" "	—	—	—	—	—	—	—	—	—	2·25	175	1,538	352	4·76	309	4·10	182	832	212	970
9	Hollister, California .	1896	12	—	1⅜	Redwood	⅝ inch rolled thread ..	6,000	10	23	—	—	599	169	8·59	1,125	3·45	103	575	266	1,417
	" " ..	—	—	..	—	—	—	—	—	—	2·75	100	716	201	7·20	309	5·38	129	686	172	918
	" " .	—	14	—	$1\frac{5}{32}$	—	⅝ inch rolled thread ..	—	11	22	—	—	735	182	7·20	1,272	3·01	112	600	258	1,430
	" " ..	—	—	—	—	—	—	—	—	—	2·75	100	835	207	6·33	318	4·85	128	680	167	889
10	St. Paul, Minnesota ..	1893	42	1·50	1⅜	Fir ..	½ inch plain ..	7,500	14	5	—	—	638	80	10·45	2,450	2·36	32	128	141	563
	" " ..	—	—	—	—	—	—	—	—	—	4·00	25	911	114	7·32	700	4·35	46	182	77	306
11	West Los Angeles, California	1893	30	7·50	1¼	Redwood	½ inch rolled thread ..	11,800	12	20	—	—	1,562	276	6·42	1,800	3·25	111	446	220	882
	West Los Angeles, California	—	—	—	—	—	—	—	—	—	3·50	105	2,370	355	4·33	525	3·63	165	660	197	788
12	Ogden, Utah . .	1897	72	5·10	2·00	Fir ..	⅝ inch upset ..	18,400	5·25	55	—	—	4,490	374	3·78	1,050	3·11	128	409	156	487
	" "	—	—	—	—	—	—	—	—	—	2·875	100	4,490	374	3·78	575	3·38	128	409	143	447
	" " ..	—	—	—	—	—	—	26,400	[illegible]	—	3·54	117	6,471	539	3·77	708	3·42	184	492	170	454
	West Los Angeles California	1898	14	7·50	1¼	Redwood	⅝ inch upset ..	5,500	10·00	20	—	—	605	194	6·88	1,125	2·81	98	524	237	1,264
	West Los Angeles, California	—	—	—	—	—	—	—	—	—	4·50	66	898	217	4·93	506	3·40	137	730	166	885

TABLE II.—COMPARATIVE COST OF PIPE AT CHICAGO (INCLUDING LAYING, BUT NOT HAULING).

Nominal Diameter.	Stave.				Steel Riveted.								Cast-iron.			
	25 Feet Head.	50 Feet Head.	100 Feet Head.	200 Feet Head.	No. 14, B.W.G.	No. 12, B.W.G.	No. 10, B.W.G.	No. 8, B.W.G.	No. 6, B.W.G.	¼ Inch.	$\frac{5}{16}$ Inch.	⅜ Inch.	25 Feet Head.	50 Feet Head.	100 Feet Head.	200 Feet Head.
Inches.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
12	1 9	2 0½	2 7¼	3 6¼	1 4	1 7	1 10	—	—	—	—	—	3 0¼	3 2¼	3 6	4 2
18	2 10¼	3 4	4 3	6 1	—	2 4¼	2 8¼	3 3	4 1	—	—	—	5 4¼	5 7¼	6 1	7 1
24	3 3¼	3 9¼	4 9	6 8½	—	—	3 6¼	4 4	5 4	6 5¼	8 3¼	—	7 11¼	8 4	9 1	10 7¼
30	4 0	4 8	6 0	8 7	—	—	—	5 3¼	6 7½	8 0½	10 3	12 8	11 1¼	11 8	12 0½	15 0¼
36	4 11½	5 10	7 7	11 0¼	—	—	—	6 5¼	8 0¼	9 7	12 2	14 11	14 5¼	15 3¼	16 11	20 2¼
42	5 10	7 0	9 3¼	13 10¼	—	—	—	6 8½	9 1	11 1	14 0¼	17 2	18 5	19 6½	21 9	26 2
48	6 5½	7 8½	10 3	15 3¼	—	—	—	—	10 4	12 7¼	15 11¼	19 5	22 11	24 4	27 3½	33 0
54	9 3¼	10 11	14 3¼	20 11	—	—	—	—	11 8	14 2¼	17 10¼	21 8½	27 8½	29 7	33 4	47 9
60	11 10½	13 11¼	18 2½	26 8	—	—	—	—	—	15 9¼	19 9¼	23 11	33 6	35 11½	40 10	50 6¼
66	13 4½	15 10½	20 10	30 9	—	—	—	—	—	18 1¼	21 8¼	26 2¼	39 7½	42 4	48 1¼	58 6¼
72	15 2¼	18 3	24 3¼	34 5½	—	—	—	—	—	18 10	23 7	28 5½	47 2	50 0	55 3	66 8

TABLE III.—COMPARATIVE COST OF PIPE AT SAN FRANCISCO (INCLUDING LAYING, BUT NOT HAULING).

Nominal Diameter.	Stave.				Steel Riveted.								Cast-iron.			
	25 Feet Head.	50 Feet Head.	100 Feet Head.	200 Feet Head.	No. 14, B.W.G.	No. 12, B.W.G.	No. 10, B.W.G.	No. 8, B.W.G.	No. 6, B.W.G.	¼ Inch.	$\frac{5}{16}$ Inch.	⅜ Inch.	25 Feet Head.	50 Feet Head.	100 Feet Head.	200 Feet Head.
Inches.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
12	1 6½	1 10¼	2 6¼	3 11	1 10¼	2 2	2 6	—	—	—	—	—	3 11	4 1¼	4 6¼	5 5¼
18	2 5	2 11¼	4 0	6 1½	—	3 2¼	3 8	4 4	5 5	—	—	—	6 10¼	7 3½	7 10½	9 2¼
24	3 2	4 0	5 7¼	8 10	—	—	4 2¼	5 7¼	6 11¼	8 2¼	10 5¼	—	10 5	10 11	11 11	14 0¼
30	3 7½	4 3¼	5 11¼	9 3½	—	—	—	6 10	8 6	10 2¼	12 11	15 9¼	14 8	15 5	16 11¼	20 0¼
36	4 3	5 4¼	7 7¼	12 1	—	—	—	7 6	10 2	12 2	15 3¼	18 8¼	19 2	20 3¼	22 6	27 1
42	5 1½	6 7	9 6	15 4¼	—	—	—	9 5¼	11 8	14 0¼	17 8	21 4	24 5¼	26 0¼	29 0¼	35 1¼
48	5 7	7 2¼	10 5¼	16 11¼	—	—	—	—	13 1	15 10	19 11	24 1	30 6¼	32 6	36 4¼	44 4
54	8 1	10 2¼	14 6¼	28 0	—	—	—	—	14 9¼	18 0	22 4¼	26 11¼	36 11	39 5¼	44 6¼	54 9¼
60	10 2	12 10¼	18 3¼	29 2	—	—	—	—	—	20 3¼	24 9¼	30 2	44 8¼	48 1	54 9	68 0¼
66	11 7½	14 10¼	25 5	34 5	—	—	—	—	—	22 7¼	27 3	32 6¼	52 11	57 0¼	64 4¼	78 10
72	13 5	17 3½	23 2	40 9	—	—	—	—	—	24 7	29 6¼	35 5	63 0	66 10¼	74 1	89 8¼

M. W. B.

MOTIVE POWER FROM BLAST-FURNACE GAS.

Expériences sur l'Emploi direct des Gaz des Hauts-Fourneaux dans les Machines motrices. By A. WITZ. *Revue Universelle des Mines, etc.*, 1898, *vol. xliii., page* 113.

These experiments were undertaken for studying the actual conditions under which a large single-cylinder gas engine worked, when supplied with gas from a coke-fired blast-furnace; and a trial of sufficient length was made for proving that blast-furnace gases, used directly, permit of regular and continuous working, notwithstanding any variations in quality, richness and pressure, and also the large quantity of dust. It was decided to submit the 200 horsepower simplex gas engine, with a cylinder of 31½ inches (80 centimetres) diameter, and 39⅜ inches (1 metre) stroke, running at 105 revolutions per minute, to a trial of 24 consecutive hours, with its normal load and a maximum of 90 admissions per cent., supplied with gas as it left the blast-furnaces, either directly or after passing through a gasometer of about 10,000 cubic feet (300 cubic metres) capacity.

The engine produces 181 horsepower, measured by the brake, almost without variation during 24 hours, with a mean consumption of 117·6 cubic feet (3·329 cubic metres) per effective horsepower per hour of gas, the calorific power of which remained near upon 1,766 British thermal units per pound (981 calories per kilogramme), while consuming nearly 22 gallons (100 litres) of water and less than ½ ounce (18 grammes) of oil and grease, while the working was quite as regular as that of a steam-engine, and the dust in the gas did not interfere with its working. J. W. P.

WIRELESS TELEGRAPHY AND TRANSMISSION OF POWER.

La Télégraphie sans Fil. By — CLERMONT. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1898, *pages* 110-111.

Röntgen or cathodic rays, Hertz waves, the emanations employed in wireless telegraphy by Messrs. Marconi and Chunder Bose, all result from one and the same manifestation of electricity. In accordance with Prof. Maxwell's theory, sound, light and electricity are only vibrations of luminous ether, differing from one another by the speed and amplitude of the undulations, which vary between a few thousands per second in sound, to 700 trillions in the violet ray, so that man may now be justly considered to possess a new element, the full application of which cannot at present be determined. If the manner in which electricity is outwardly manifested differ from that in which it has hitherto been applied, the results are very different, and sometimes, it may be said, opposed.

The effects of the Röntgen rays are wellknown; but there is little doubt that they are susceptible of many other than their present applications. For instance, Prof. Ebert, who has made many experiments for utilizing the luminosity produced by these rays, declares that it will constitute the lighting of the future. The principle of wireless telegraphy, discovered simultaneously by Mr. Marconi in London and Mr. Chunder Bose at Calcutta, depends upon the production of electric waves by a current of high frequency, traversing a Ruhmkorff coil and actuating a Hertz resonator, the vibrations of ether, transmitted to a considerable height, being distributed through the atmosphere; and for collecting them a resonator is required, which afterwards transmits them to the telegraphic or telephonic apparatus. With this arrangement, a body, or substance, is obtained,

normally non-conducting, but which becomes conducting under the action of the electric waves, and continues in this state until the coherence is destroyed by external shock, after the passage of each fraction of current necessary.

Wireless telegraphy by electric waves has not as yet received all the application of which it is susceptible; and there is little doubt that this new form of utilizing electricity will, in the more or less near future, be attended with very pregnant results, not only in telegraphy, but even in the transmission of power.

J. W. P.

OFFICIAL REGULATIONS AS TO FOREIGN-SPEAKING WORKMEN IN WESTPHALIAN MINES.

Bergpolizeiverordnung betreffend die Beschäftigung fremdsprachiger Arbeiter beim Bergwerksbetriebe im Oberbergamts-Bezirke Dortmund, (*signed*) TAEGLICHSBECK, *January 25th*, 1899.

In the interests of safety, foreign-speaking workmen may henceforth only be employed in mines and their dependencies (coke-ovens not coming under this regulation) provided they are sufficiently acquainted with the German language to understand the verbal orders of their chiefs and the communications of their fellow-workmen. In the responsible positions of overmen, shot-firers, leading and ventilation hands, onsetters, brakesmen, banksmen, enginemen, boiler-minders, engine-drivers, signal-men, pointsmen and a few others, foreigners may be employed only if they can speak German and read that language, written as well as printed, though this does not apply to men who may temporarily be called upon to discharge the duties of the abovenamed officials and workmen. Lists must be kept of all foreign workmen employed in mines, including the preparation-plants and fuel-works belonging to them; and the manager or his representative is held responsible for the correctness of such lists. Foreigners employed at the mines on the date of the order are, however, exempted from its provisions until after a lapse of 6 months; and that period may be extended by the Mining Authority to 18 months on the application of the mine-owner.

J. W. P.

DECIMAL MEASUREMENT OF TIME AND ANGLES.

Application du Système décimal à la Mesure du Temps et des Angles. By — DE REY-PAILHADE. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1898, *pages* 184-185.

The time has now arrived for applying the decimal system to the measurement of time and also angles for simplifying calculation, while with a little practice the time can easily be read in the decimal manner. In the author's system, the day and the circumference of the circle are divided into 100 equal parts, the new units being called respectively "cé" and "cir," with their decimal subdivisions "decicé, decicir" and "centicé, centicir," etc.

The author showed some watches with double graduation, both horary and decimal, a miner's dial and a sextant decimally divided, and also maps and charts to decimal scales, with conversion-tables, and observed that the system might be applied to physics, navigation, mechanics and electricity. J. W. P.

II.—REPORT OF THE CORRESPONDING SOCIETIES COMMITTEE OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, BRISTOL, 1898.*

The following Corresponding Societies nominated as delegates to represent them at the Bristol meeting:- Chesterfield and Midland Counties Institution of Engineers, Mr. M. H. Mills, M.Inst.C.E.; The Institution of Mining Engineers, Mr. M. H. Mills, M.Inst.C.E.; Mining Institute of Scotland, Mr. James Barrowman; North of England Institute of Mining Engineers, Mr. T. Forster Brown, M.Inst.C.E.

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First meeting of the Conference, Bristol, September, 8, **1898.**

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The following Societies have been added to the list of the Corresponding Societies: -

The Astronomical and Physical Society of Toronto.

The Hull Geological Society.

The South Eastern Union of Naturalists' Societies.

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Dr. Abbott wished to know if there would be any opportunity of discussing the subject of the Federation of Local Societies at that meeting of the British Association. The Chairman thought that it might be brought forward at the next meeting of the Conference.

Second meeting of the Conference, September **13, 1898.**

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UNIFORMITY OF SIZE OF PAGES OF SCIENTIFIC SOCIETIES' PUBLICATIONS.

Prof. S. P. Thompson said that he had been asked to bring before the Conference a matter on which a Committee of the British Association had already made one Report, and still continued to exist, with the intention of making another.

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The standard octavo size recommended was:—Paper *demy*, the pages measuring 14 centimetres by 22 centimetres, or, when uncut, 5⅝ inches by 8¾ inches. The width, measured from the stitching to the outer edge of the printed matter, to be 12 centimetres, or 4¾ inches, and the height of the printed portion, including the running headline, to be 18 centimetres, or 7 inches.

The standard quarto size:--Paper *demy*, the pages measuring, when uncut, 22 centimetres by 28·5 centimetres, or 8¾ inches wide by 11 inches high. Letterpress not to exceed the measurements of 7½ inches by 9 inches.

It was also desirable that each article should begin a page, and that, if possible, it should begin on a right-hand page. It is, then, practicable to bind that article with others without binding up with it the last page of another.

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Mr. Clement Reid suggested that the old paging should be preserved in reprints.

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* Reprinted by permission of the Council of the British Association for the Advancement of Science.

Committees appointed by the General Committee at the Bristol Meeting in September, 1898.

1.—Receiving Grants of Money.

Subject for Investigation or Purpose.	Members of the Committee.	Grants.
		£ s. d.
Seismological observations	*Chairman.*—Prof. J. W. Judd. *Secretary.*—Prof. J. Milne. Lord Kelvin, Sir F. J. Bramwell, Prof. G. H. Darwin, Mr. Horace Darwin, Major L. Darwin, Prof. J. A. Ewing, Prof. C. G. Knott, Prof. R. Meldola, Prof. J. Perry, Prof. J. H. Poynting, Prof. T. G. Bonney, Mr. C. V. Boys, Prof. H. H. Turner, Mr. G. J. Symons, and Dr. C. Davison.	75 0 0
To assist the publication of "Science Abstracts."	*Chairman*—Prof. A. W. Rücker. *Secretary*—Prof. W. E. Ayrton. Captain Abney and Prof. S. P. Thompson.	100 0 0
The collection, preservation, and systematic registration of photographs of geological interest.	*Chairman.*—Prof. J. Geikie. *Secretary.*—Prof. W. W. Watts. Prof. T. G. Bonney, Dr. T. Anderson, and Messrs. A. S. Reid, E. J. Garwood, W. Gray, H. B. Woodward, J. E. Bedford, R. Kidston, R. H. Tiddeman, J. J. H. Teall, J. G. Goodchild, H. Coates, and C. V. Crook.	10 0 0
To study life-zones in the British Carboniferous rocks.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Mr. E. J. Garwood. Mr. F. A. Bather, Mr. G. C. Crick, Mr. A. H. Foord, Mr. H. Fox, Dr. Wheelton Hind, Dr. G. J. Hinde, Mr. P. F. Kendall, Mr. J. W. Kirkley, Mr. R. Kidston, Mr. G. W. Lamplugh, Prof. G. A. Lebour, Mr. G. H. Morton, Prof. H. A. Nicholson, Mr. B. N. Peach, Mr. A. Strahan, and Dr. H. Woodward.	10 0 0
Corresponding Societies Committee for the preparation of their Report.	*Chairman.*—Prof. R. Meldola. *Secretary.*—Mr. T. V. Holmes. Mr. Francis Galton, Sir Douglas Galton, Mr. G. J. Symons, Dr. J. G. Garson, Sir John Evans, Mr. J. Hopkinson, Prof. T. G. Bonney, Mr. W. Whitaker, Sir Cuthbert E. Peek, Mr. Horace T. Brown, Rev. J. O. Bevan, and Prof. W. W. Watts.	25 0 0
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2.—Not Receiving Grants of Money.

Subject for Investigation or Purpose.	Members of the Committee.
To confer with British and foreign societies publishing mathematical and physical papers as to the desirability of securing uniformity in the size of the pages of their Transactions and Proceedings.	*Chairman.*—Prof. S. P. Thompson. *Secretary.*—Mr. J. Swinburne. Prof. G. H. Bryan, Mr. C. V. Burton, Mr. R. T. Glazebrook, Prof. A. W. Rücker, and Dr. G. Johnstone Stoney.
The rate of increase of underground temperature downwards in various localities of dry land and under water.	*Chairman.*—Prof. J. D. Everett. *Secretary.*—Prof. J. D. Everett. Prof. Lord Kelvin, Mr. G. J. Symons, Sir A. Geikie, Mr. J. Glaisher, Prof. Edward Hull, Dr. C. Le Neve Foster, Prof. A. S. Herschel, Prof. G. A. Lebour, Mr. A. B. Wynne, Mr. W. Galloway, Mr. Joseph Dickinson, Mr. G. F. Deacon, Mr. E. Wethered, Mr. A. Strahan, Prof. Michie Smith, and Prof. H. L. Callendar.
To consider the best methods for the registration of all type specimens of fossils in the British Isles, and to report on the same.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Mr. A. Smith Woodward. Rev. G. F. Whidborne, Mr. R. Kidston, Prof. H. G. Seeley, and Mr. H. Woods.
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THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1898-99.

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Andersonian Naturalists' Society, 1885	Andersonian Nat. Soc.	201, George Street, Glasgow. A. D. Brownlie and C. Cunningham	181	None	2s. 6d.	Annals, occasionally.
Bath Natural History and Antiquarian Field Club, 1855	Bath N. H. A. F. C. ..	Rev. W. W. Martin, Royal Literary and Scientific Institution, Bath	100	5s.	10s.	Proceedings, annually.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square. R. M. Young, B.A.	258	None	£1 1s.	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1862..	Belfast Nat. F. C. ..	Museum, College Square. James St. J. Phillips	450	5s.	5s.	Report and Proceedings, annually.
Berwickshire Naturalists' Club, 1831..	Berwicksh. Nat. Club ..	Dr. J. Hardy, Old Cambus, Cockburnspath, N.B., and Rev. G. Gunn, M.A., Stichill, Kelso, N.B.	400	10s. 6d.	7s. 6d.	History of the Berwickshire Naturalists' Club, annually.
Birmingham Natural History and Philosophical Society, 1858	Birm. N. H. Phil. Soc.	Norwich Union Chambers, Congreve Street, Birmingham. W. P. Marshall and W. Boulton	254	None	£1 1s.	Journal, bi-monthly; Proceedings, annually.
Brighton and Hove Natural History and Philosophical Society, 1854	Brighton N. H. Phil. Soc.	E. A. Pankhurst, 3, Clifton Road, Brighton, and T. C. Clark	178	10s.	10s.	Report, annually
Bristol Naturalists' Society, 1862 ..	Bristol Nat. Soc. ..	Theodore Fisher, M.D., 25, Pembroke Road, Clifton, Bristol	136	5s.	10s.	Proceedings, annually.
Buchan Field Club, 1887	Buchan F. C.	J. F. Tocher, F.I.C., 5, Chapel Street, Peterhead	170	5s.	5s.	Transactions, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc..	B. L. Oswell, 71, Spring Terrace Road, Burton-on-Trent	200	None	5s.	Annual Report. Transactions, occasionally
Caradoc and Severn Valley Field Club, 1893	Car. & Sev. Vall. F. C...	H. E. Forrest, 37, Castle Street, Shrewsbury	185	5s.	5s.	Transactions and Record of Bare Facts, annually.
Cardiff Naturalists' Society, 1867 ..	Cardiff Nat. Soc. ..	Walter Cook, 98, St. Mary Street, Cardiff	453	None	10s. 6d.	Transactions, annually.
Chester Society of Natural Science and Literature, 1871	Chester Soc. Nat. Sci...	Grosvenor Museum, Chester. G. P. Miln and W. F. J. Shepheard	700	None	5s.	Annual Report. Proceedings, occasionally.
Chesterfield and Midland Counties Institution of Engineers, 1871	Chesterf. Mid. Count. Inst.	Stephenson Memorial Hall. W. F. Howard, 15, Cavendish Street, Chesterfield	[illegible]53	£1 1s None	Members, 31s. 6d.; Associates and Students, 20s.	"Transactions of The Institution of Mining Engineers," about every month.
Cornwall, Mining Association and Institute of, 1859	Cornw. Min. Assoc. Inst.	William Thomas, C.E., F.G.S., Penelvan, Camborne	180	10s. 6d.	Minimum, 10s. 6d.	Transactions, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc. ..	John B. Cornish, Penzance	98	None	£1 1s.	Report and Transactions, annually
Croydon Microscopical and Natural History Club, 1870	Croydon M. N. H. C. ..	Public Hall, Croydon. R. F. Grundy	230	None	10s.	Proceedings and Transactions, annually.
Dorset Natural History and Antiquarian Field Club, 1875	Dorset N. H. A. F. C. ..	Nelson M. Richardson, Montevideo, Chickerell, Weymouth	350	None	10s.	Proceedings, annually.
Dublin Naturalists' Field Club, 1885	Dublin N. F. C.	Prof. T. Johnson, Science and Art Museum, Dublin	200	5s.	5s.	"Irish Naturalist," monthly. Report, annually.
Dumfriesshire and Galloway Natural History and Antiquarian Society, 1862	Dum. Gal. N. H. A. Soc.	Dr. J. Maxwell Ross, Avenel, Dumfries	190	2s. 6d.	5s.	Transactions and Journal of Proceedings, annually.
East Kent Natural History Society, 1857	E. Kent N. H. Soc. ..	18, Watling Street, Canterbury. Stephen Horsley	58	None	10s.	"South Eastern Naturalist," annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1898-99.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
East of Scotland Union of Naturalists' Societies, 1884	E. Scot. Union	William D. Sang, Tylehurst, Kirkcaldy, N.B.	10 Societies, 900 Membs.	None	Assessment of 4d. per member	Proceedings, occasionally.
Edinburgh Geological Society, 1834..	Edinb. Geol. Soc. ..	H. M. Cadell, B.Sc., 5, St. Andrew Square, Edinburgh	253	10s. 6d.	12s. 6d.	Transactions, annually.
Essex Field Club, 1888	Essex F. C.	William Cole, 7, Knighton Villas, Buckhurst Hill, Essex	350	None	15s.	"Essex Naturalist," quarterly, and "Special Memoirs," occasionally.
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc. ..	J. Barclay Murdoch, Capelrig, Mearns, Glasgow	250	None	10s.	Transactions, annually.
Glasgow, Natural History Society of, 1851	Glasgow N. H. Soc. ..	S. M. Wellwood, 207, Bath Street, Glasgow	332 Members 30 Associates	7s. 6d. None	Members 7s. 6d. Associates 5s	Transactions and Proceedings, annually
Glasgow, Philosophical Society of, 1802	Glasgow Phil. Soc. ..	A. Freeland Fergus, M.D., 207, Bath Street, Glasgow	650	£1 1s.	£1 1s.	Proceedings, annually.
Halifax Scientific Society and Geological Field Club, 1874	Halifax S. S. G. F. C. .	Literary and Philosophical Society's Rooms. C. E. Fox	110	None	2s. 6d.	"Halifax Naturalist," every two months
Hampshire Field Club, 1885	Hants. F. C.	Hartley Institution, Southampton. W. Dale, F.G.S.	250	None	7s. 6d.	Proceedings, annually.
Hertfordshire Natural History Society and Field Club, 1875	Herts. N. H. Soc. ..	John Hopkinson, F.L.S., The Grange, St. Albans	220	10s.	10s.	Transactions, quarterly.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C. ..	A. J. Crosfield, Carr End, Reigate	83	10s.	10s.	Proceedings, every two or three years.
Hull Geological Society, 1887 ..	Hull Geol. Soc. .. .	Royal Institution. John W. Stather	65	None	5s.	Transactions, annually.
Institution of Mining Engineers ..	Inst. Min. Eng.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	2,500	None	None	Transactions, about every month.
Inverness Scientific Society and Field Club, 1875	Inverness Sci. Soc. .	E. G. Critchley, 29, High Street, Inverness	175	None	5s. and 2s.	Transactions, occasionally.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland ..	J. Pim, W. Lawson and C. H. Oldham, 35, Molesworth Street, Dublin	100	None	£1.	Journal, annually.
Leeds Geological Association, 1874 ..	Leeds Geol. Assoc. .	Dr. D. Forsyth, 2, Lifton Place, Leeds	100	None	5s., 2s. 6d., and 1s.	Transactions, annually.
Leeds Naturalists' Club and Scientific Association, 1868	Leeds Nat. C. Sci. Assoc.	H. B. Wilson, Westfield, Armley, Leeds; E. B. Smith, St. Chad's Villa, Headingley, Leeds	170	None	6s.	Transactions, occasionally.
Leicester Literary and Philosophical Society, 1835	Leicester Lit. Phil. Soc.	Corporation Museum. J. M. Gimson	320 Members & Associates.	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions, quarterly.
Liverpool Engineering Society, 1875..	Liv'pool E. Soc.	R. C. F. Annett, Royal Institution, Liverpool	383	None	Resident, £1 1s.; Non-res., and Students, 10s. 6d.	Transactions, annually.
Liverpool Geographical Society, 1892	Liv'pool Geog. Soc. ..	Capt. E. C. Dubois Phillips, R.N., 14, Hargreave's Buildings, Chapel Street, Liverpool	750	None	£1 1s.	Transactions and Report, annually.
Liverpool Geological Society, 1858 ..	Liv'pool Geol. Soc. ..	Royal Institution. H. C. Beasley	55	None	£1 1s.	Proceedings, annually.
Liverpool, Literary and Philosophical Society of, 1812	Liv'pool Lit Phil. Soc...	Royal Institution. J. Maxwell McMaster	214	None	£1 1s.; Ladies, 10s. 6d.	Proceedings, annually.
Malton Field Naturalists' and Scientific Society, 1879	Malton F. N. Sci. Soc...	Museum, Yorkersgate, Malton, Yorkshire. F. Young	100	None	5s. and 2s. 6d.	Report, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1898–99.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Man, Isle of, Natural History and Antiquarian Society, 1879	I. of Man N. H. A. Soc.	P. M. C. Kermode, Hillside, Ramsey, Isle of Man	143	2s. 6d.	Gentlemen, 7s. 6d. Ladies and Non-Residents, 5s.	Yn Lioar Manninagh, biennially.
Manchester Geographical Society, 1884	Manch. Geog. Soc. ..	Eli Sowerbutts, F.R.G.S., 16, St. Mary's Parsonage, Manchester	800	None	Members, £1 1s.; Associates, 10s. 6d.	Journal, quarterly; "Geography," monthly
Manchester Geological Society, 1838 ..	Manch. Geol. Soc. ..	5, John Dalton Street, Manchester. W. Saint and G. H. Winstanley	265	None	£1.	Transactions, eight or nine parts per annum.
Manchester Microscopical Society, 1880	Manch. Mic. Soc. ..	E. C. Stump, 16, Herbert Street, Moss Side, Manchester	213	5s.	6s.	Transactions and Report annually.
Manchester Statistical Society, 1833 ..	Manch. Stat. Soc. ..	63, Brown Street, Manchester. F. E. M. Beardsall and T. Gregory	103	10s. 6d.	10s. 6d.	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick ..	353	1s. 6d.	3s. and 5s.	Report, annually.
Midland Institute of Mining, Civil and Mechanical Engineers, 1869	Mid. Inst Eng. ..	T. W. H. Mitchell, Mining Offices, Barnsley	250	None	£1 10s.	"Transactions of The Institution of Mining Engineers," about every two months.
Norfolk and Norwich Naturalists' Society, 1869	Norf. Norw. Nat. Soc.	W. A. Nicholson, St. Helen's Square, Norwich	256	None	5s.	Transactions, annually.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	1,200	None	21s. and 42s.	"Transactions of The Institution of Mining Engineers," about every month.
North Staffordshire Field Club ..	N. Staff. F. C. ..	Rev. T. W. Daltry, M.A., Madeley Vicarage, Newcastle, Staffs.	400	5s.	5s.	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	N'ton N. H. Soc. ..	H. N. Dixon, M.A., 23, East Park Parade, Northampton	150	None	10s.	Journal, quarterly.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	Henry Wilkins, 352, Alfreton Road, Nottingham	171	2s. 6d.	5s.	Report, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst. ..	J. Gardner, 3, County Place, Paisley	392; 22 Associates	5s.	7s. 6d.	Report, annually; Meteorological Observations, occasionally.
Penzance Natural History and Antiquarian Society, 1839	Penz. N. H. A. Soc. ..	Museum, Public Buildings, Penzance. Dr. H. Montgomerie	80	None	10s. 6d.	Report, annually.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci. ..	Tay Street, Perth. S. T. Ellison ..	312 Members; 40 Associates	2s. 6d.	5s. 6d.	Transactions and Proceedings, annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, B.Sc., 105, Freehold Street, Rochdale	238	None	6s.	Transactions, biennially.
Rochester Naturalists' Club, 1878 ..	Rochester N. C.	John Hepworth, Linden House, Rochester	130	None	5s.	"Rochester Naturalist," quarterly.
Scotland, Mining Institute of	Mining Inst. Scot. ..	James Barrowman, Staneacre, Hamilton, N.B.	466	None	42s. and 25s.	"Transactions of the Mining Institute of Scotland," six times each year.
Somersetshire Archæological and Natural History Society, 1848	Som'setsh. A.N.H. Soc.	The Castle, Taunton. Lt.-Col. J. R. Bramble and Rev. F. W. Weaver	600	10s. 6d.	10s. 6d.	Proceedings, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1898–99.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
South African Philosophical Society, 1877	S. African Phil. Soc. ..	L. Péringuey, South African Museum, Cape Town	123	None	£2 and £1.	Transactions, annually.
South-Eastern Union of Scientific Societies, 1896	S.-E. Union	George Abbott, M.R.C.S., 33, Upper Grosvenor Road, Tunbridge Wells	31 Societies	None	5s.	Transactions, annually.
South Staffordshire and East Worcestershire Institute of Mining Engineers, 1867	S. Staff. Inst. Eng. .	Alexander Smith, M. Inst. C.E., 3, Newhall Street, Birmingham	167	£1 1s. and 10s. 6d.	31s. 6d. and 21s.	"Transactions of The Institution of Mining Engineers," about every month.
Toronto, Astronomical and Physical Society of	Toronto Astr. Phys. Soc.	Technical School Buildings. G. E. Lumsden	133	—	—	Transactions, annually.
Tyneside Geographical Society, 1887 ..	Tyneside Geog. Soc. ..	Geographical Institute, Barras Bridge, Newcastle-upon-Tyne. G. E. T. Smithson	1,300	None	10s. and 5s.	Journal, half-yearly.
Warwickshire Naturalists' and Archæologists' Field Club, 1858	Warw. N. A. F. C. ..	Museum, Warwick. T. W. Whitley, 20, Camberwell Terrace, Leamington	84	2s. 6d.	5s.	Proceedings, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C. ..	Woolhope Club Room, Free Library, Hereford. H. Cecil Moore	219	10s.	10s.	Transactions, biennially.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	Rev. Wm. Lower Carter, F.G.S., Hopton, Mirfield	163	None	13s.	Proceedings, annually.
Yorkshire Naturalists' Union, 1861 ..	Yorks. Nat. Union ..	W. Denison Roebuck, F.L.S., 259, Hyde Park Road, Leeds	431 and 2,383 Associates	None	Members 10s. 6d.	Transactions, annually; "The Naturalist," monthly.
Yorkshire Philosophical Society, 1822	Yorks. Phil. Soc. ..	Museum, York. Dr. Tempest Anderson and C. E. Elmhirst	410	None	£2	Report, annually.

INDEX OF THE MORE IMPORTANT PAPERS, AND ESPECIALLY THOSE REFERRING TO LOCAL SCIENTIFIC INVESTIGATIONS, PUBLISHED BY NAMED SOCIETIES DURING THE YEAR ENDING JUNE 1, 1898.*

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Section K.—BOTANY.

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EXPLANATIONS.

The — at the beginning of a line denotes the repetition of a word; and in the case of Names, it includes both the Christian Name and the Surname.

Discussions are printed in *italics*.

The following contractions are used:—

C.—Chesterfield and Midland Counties Institution of Engineers.

M.—Midland Institute of Mining, Civil and Mechanical Engineers.

S.—Mining Institute of Scotland.

N.E.—North of England Institute of Mining and Mechanical Engineers.

N.S.—North Staffordshire Institute of Mining and Mechanical Engineers.

S.S.—South Staffordshire and East Worcestershire Institute of Mining Engineers.